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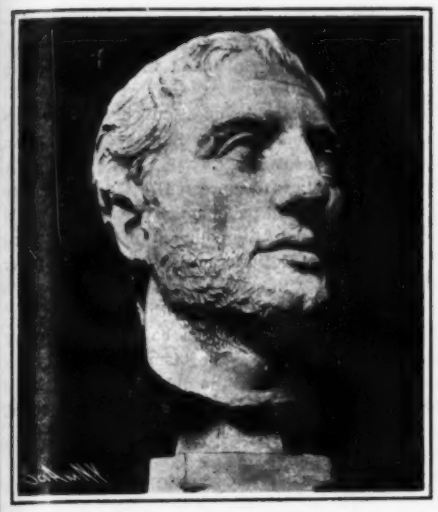


LIFE SIZE HEAD.

THE "TREASURE OF CNIDIANS," PART OF A SCULPTURED FRIEZE.

PART OF FRIEZE "TREASURE OF CNIDIANS."

FEMALE STATUE, LIFE SIZE.

WINGED SPHINX.

PART OF THE FRIEZE "TREASURE OF CNIDIANS."

A PHILOSOPHER.

EXCAVATIONS AT DELPHI.

EXCAVATIONS AT DELPHI.

By the Paris Correspondent of SCIENTIFIC AMERICAN.

THE excavations which have been recently made at Delphi by the French School of Athens, under the direction of M. Homolle, are already showing some remarkable results. When the excavations were commenced some years ago, the village of Kastri covered the ancient site and the first discoveries were made in the midst of the village. In order to carry on the excavations, the whole village had to be displaced, and this was not without some resistance on the part of the inhabitants, as might be imagined, but at present they have become reconciled to their new quarters.

The sacred inclosure of Delphi is a large area of rectangular shape which extends up the slope of the mountain. This area is surrounded by a wall which has been uncovered throughout its whole extent. A series of gates, corresponding to the different levels or terraces, lead into the inclosure. The interior space of the inclosure is divided into three different regions which rise one above the other. In the central part is the terrace which has been leveled by means of a large embankment at the lower part and here the front part of the terrace is faced and upheld by a long and high wall known as the Polygonal Wall, from the shape of the massive blocks which compose it. Upon the flat terrace was situated the Temple of Apollo, a large and magnificent structure, of which only the foundations are to be seen at present. In the center of the temple was the sacred spring or pool of the Oracle, formed of a large rectangular opening in the foundation, below which the water flowed.

The main entrance to the sacred inclosure is in the lower or southeastern part, and after passing the gate we come upon the Sacred Way, which winds up the slope and finally reaches the terrace of the temple. This route is paved with large flagstones which are well preserved in most places and date from the Roman period. Along the way were to be found in former times the handsome structures or votive offerings which were dedicated to Apollo by different nations, kings or private individuals, out of gratitude for the services which the oracle had rendered them by its predictions. Each of the Hellenic peoples had its particular structure or Treasure, which was usually in the form of a small and well-ornamented temple containing a series of trophies and other rich offerings to the divinity. Besides the larger structures we find many smaller commemorative offerings in the shape of ornamented columns, statues or votive groups by the most celebrated sculptors. Life-sized chariot groups of bronze mounted upon massive pedestals, bronze tripods and precious vases were placed throughout the inclosure. The illustrious families were here represented by a series of statues showing their different members, and effigies of kings and generals were abundant. Prominent among the rich trophies were the splendid offerings of the Kings of Asia and the Tyrants of Sicily.

The Sacred Way mounts up along the south wall of the main space and reaches a small area or paved square, around which were grouped many of the principal votive structures. From this point the route makes an abrupt turn and mounts diagonally up to the main terrace of the Temple. The structures and monuments which filled the area below the temple must have presented a most brilliant spectacle in its varied richness, but they have almost entirely disappeared at the present time, and of most of the structures only the foundations are left above ground. Fortunately some of them have been preserved in an almost complete state, and they give a good idea of what the ensemble must have been like. But even these monuments were not found intact by any means, and the fragments had to be carefully put together in order to reconstruct the whole. The most important of the structures of Delphi which have been built up in this way under M. Homolle's direction is the Treasure of the Cnidian nation. It has the form of a small temple. The style of this monument belongs to the end of the sixth century B. C. and lies therefore in the early period of Hellenic art. The rectangular building has a projecting fronton which is supported by two caryatides, considerably larger than life size. The engravings show a part of the frieze which surrounds the upper part of the structure, and it gives a good idea of the high state of the Ionian art at the end of the sixth century. The discovery of the frieze gives us a valuable addition to our knowledge of Greek art during the early period. The subject of the frieze represents the combat of warriors, and the details of the armor and weapons of this epoch will be remarked. The composition of the groups is remarkable and the reliefs are executed with great care. Here we have a varied and animated scene and the groups are formed into a harmonious whole. Another structure of equal interest is the Treasure of the Athenians which also has the form of a small temple. M. Homolle expects to be able to reconstruct it upon the spot, like the former one, aided by the municipality of Athens, from which the funds will probably be furnished. This monument belongs to the commencement of the fifth century B. C., and was erected at Delphi to commemorate the victory of Marathon. It belongs to the more severe Athic style, while the Cnidian structure is of the Ionic.

The lower area, which was thus crowded with ornamental edifices and monuments, is terminated at the upper end by the large polygonal wall of the temple area which we mentioned above. In front of the wall are the remains of an elegant portico built by the Athenian nation and near it is the sacred area upon which was held a symbolic drama or representation of Apollo's victory over the Python. This celebration occurred every nine years. Continuing the route we mount upon the wide floor of the temple terrace. In the central part are the foundations of the temple while the outer parts have a well-preserved paving of marble. Of the famous temple of Apollo nothing remains except the foundations, and it is remarkable to note the complete absence of the fragments of columns, cornices or other pieces which we might expect. The temple structure extended over an area of 200 feet front and 80 feet width. The interior building or cella was formed of four massive walls. Inside the cella the roof was upheld by two long ranges of Ionic columns which thus divided the space into three naves. At each end of the cella was a portico surmounted by a decorated fronton, and a spacious gallery surrounded the whole, formed of 38 Doric columns. Even in the absence of the superstructure, the foundation itself presents a remarkable interest. Here was the sanctuary of the famous Oracle. In the middle of the foundation blocks is found a large rectangular opening which goes down to some depth. Excavations which were made here, brought down to the solid rock, showed the canal by which the water was brought down from above into the cavity, forming the prophetic spring of Delphi. It is supposed that the water gave off the exhalations which caused the Pythia to give her prophetic utterances. At any rate the ancient authors give us a description of the manner in which the oracle made its prophecies. The sacred tripod was placed at the mouth of the opening and upon it was seated the Pythia who in the midst of nervous convulsions which shook all her members, gave utterance to fragments of phrases which represented the oracle of Apollo. The priests connected these phrases and interpreted them, taking care not to compromise the Oracle by a too clear meaning. Not far from the temple the basin still remains where the suppliants who were to consult the oracle were obliged to purify themselves before entering the sacred precinct. The waters of the Castalia, which supply the basin, still flow at the bottom of a narrow crevasse between two rocky masses. The space which lies above the temple contains various remains, of which the large theater, of semi-circular shape, is the most important. Here also is the source of the sacred spring, the Cassotis, which has been led down into the temple. Outside of the sacred inclosure lies the Gymnasium, situated upon two superposed terraces. The original Greek structure was completed by the Romans. Here we find the baths which are well arranged. A hot bath was added in Roman times, and the large swimming pool is still visible. At the foot of the wall are eleven basins in the flooring having above them a series of mouths placed in the wall, so as to form a series of shower-baths. Not far off is the vast stadium, where the Delphic events were held. The oblong space still has the remains of the massive blocks rising in amphitheater form which formed the seats for the spectators. Most of the smaller objects coming from the excavations are contained in the Museum, where M. Homolle expects to classify them in the near future.

OLD-FASHIONED WEATHER GLASSES: HOW THEY ARE MADE.

HERE is a method of making old-fashioned weather glasses containing a liquid that clouds or solidifies under certain atmospheric conditions:

Camphor	2½ drachms
Alcohol	11 drachms
Water	9 drachms
Saltpeter	38 grains
Sal ammoniac	38 grains

Dissolve the camphor in the alcohol and the salts in the water and mix the solutions together. Pour in test tubes, cover with wax after corking and make a hole through the cork with a red hot needle, or draw out the tube until only a pin hole remains. When the camphor, etc., appears soft and powdery, and almost filling the tube, rain with south or southwest winds may be expected; when crystalline, north, northeast or northwest winds, with fine weather, may be expected; when a portion crystallizes on one side of the tube, wind may be expected from that direction. Fine weather: The substance remains entirely at bottom of tube and the liquid perfectly clear. Coming rain: Substance will rise gradually, liquid will be very clear, with a small star in motion. A coming storm or very high wind: Substance partly at top of tube, and be of a leaflike form, liquid very heavy and in a fermenting state. These effects are noticeable twenty-four hours before the change sets in. In winter: Generally the substance lies higher in the tube. Snow or white frost: Substance very white and small stars in motion. Summer weather: The substance will lie quite low. The substance will lie closer to the tube on the opposite side to the quarter from which the storm is coming. We do not consider the instrument anything more than a scientific toy.

Strains of cotton resistant to wilt, a very destructive disease caused by a fungus living in the soil, have been developed by selection. Cowpeas resistant to root-knot and wilt have been produced, and a valuable new variety of watermelon, which will grow successfully in wilt-infected soils where other melons fail, has been developed. This was accomplished by combining the wilt-resistant qualities of the citron with the fruit quality of the melon by hybridization and selection. Flax varieties resistant to flax wilt have been produced. Considerable progress has also been made in securing by breeding and selection strains of important crops resistant to alkali.

A WORD TO OUR READERS.

IN the SCIENTIFIC AMERICAN SUPPLEMENT of December 2, 1905, is published an article by a well-known correspondent, who has contributed from time to time to the SCIENTIFIC AMERICAN and the SUPPLEMENT. The article in question was copied from an English publication, and was inserted inadvertently by one of the editors who reviews our foreign contemporaries and without the knowledge or sanction of the Editor-in-Chief.

A portion of the article consists of an attack upon the Christian religion. The SCIENTIFIC AMERICAN, during the sixty years of its career, has always maintained a position of orthodoxy. It does not intend to depart from this policy. The attitude and principle of the Editor would not admit of any different course being taken. Its position with reference to religious matters is governed not as a matter of policy, however, but as a matter of principle, and the Editor desires to state to the readers, with deep regret, that an article of the character in question should have appeared in the columns of the SCIENTIFIC AMERICAN SUPPLEMENT.

Many of the sentiments expressed in the article were altogether shocking, and under no circumstances would it have been allowed in the columns of the paper had it come under the Editor's notice before the paper went to press.

The Editor entirely disagrees with the author, that the spirit of a true religion can be replaced by any system of modern "ologies" or "isms;" certainly not by the three substitutes for the old religion which the author puts forward, namely, first, sexology; second, race culture, and third, the annihilation of creeds.

AMALGAMS: THEIR COMPOSITION, PROPERTIES, PREPARATION, AND USES.*

THE name amalgam is given to alloys of metals containing mercury. The term comes to us from the alchemists. It signifies softening, because an excess of mercury dissolves a large number of metals.

Preparation of Amalgams.—Mercury forms amalgams with most metals. It unites directly and readily, either cold or hot, with potassium, sodium, barium, strontium, calcium, magnesium, zinc, cadmium, tin, antimony, lead, bismuth, silver, and gold; directly, but more difficultly, with aluminium, copper, and palladium. This combination takes place oftenest at the ordinary temperature; certain metals, however, like aluminium and antimony, combine only when heated in presence of quicksilver.

Quicksilver has no direct action on metals of high fusing points: manganese, iron, nickel, cobalt, uranium, platinum, and their congeners. Still, amalgams of these metals can be obtained of butyrous consistency, either by electrolysis of their saline solutions, employing quicksilver as the negative electrode, or by the action of an alkaline amalgam (potassium or sodium) on their concentrated and neutral saline solutions. These same refractory metals are also amalgamated superficially when immersed in the amalgam of sodium or of ammonium in presence of water.

Processes for preparing amalgams by double decomposition between an alkaline amalgam and a metallic salt, or by electrolysis of saline solutions, with employment of mercury as the negative electrode, apply *a fortiori* to metals capable of combining directly with the quicksilver. The latter of these methods is especially utilized for the preparation of alkaline earthy metals by decomposing by means of the electric current, with quicksilver as a cathode, either the solutions of their salts or their hydrated oxides.

General Properties of Amalgams.—Amalgams are liquid when the quicksilver is in great excess; solid, but readily fusible, when the alloyed metal predominates.

They have a metallic luster, and a metallic structure which renders them brittle. They even form crystallized metallic combinations of constant proportions, dissolved in an excess of quicksilver, when the excess is separated by compression in a chamois skin, or by filtration in a glass funnel of slender stem, terminating with an orifice almost capillary.

According as the fusing heat of a metal is less or greater than its combination heat with quicksilver, the amalgamation of this metal produces an elevation or a lowering of temperature. Thus, potassium, sodium, and cadmium, in alloy with quicksilver, disengage heat; while zinc, antimony, tin, bismuth, lead, and silver combine with mercury, with absorption of heat. The amalgamation of 162 parts of quicksilver with 21 parts of lead, 12 parts of tin or of antimony, and 28.5 parts of bismuth, lowers the temperature of the mixture 26 deg. or 27 deg. C., or from +17 deg. to −10 deg. C.

Amalgams formed with disengagement of heat are electro-negative with reference to the metals alloyed with the quicksilver. The products with absorption of heat are electro-negative with reference to the metals combined with the quicksilver; consequently, in a battery of elements of pure cadmium and amalgamated cadmium, the cadmium will be the negative pole; in

* From the French of Leon de Mortillet, engineer of arts and manufactures, in the Revue de Chimie Industrielle.

case of zinc and amalgamated zinc, the zinc will be the positive pole.

Heat decomposes all amalgams, vaporizing the mercury and leaving the metal alloys as a residue.

Water is decomposed by the amalgams of potassium and sodium, because the heat of formation of these amalgams, although considerable, is yet less than the heat disengaged by potassium and sodium, on decomposing water. The alkaline amalgams may, therefore, serve as a source of nascent hydrogen in presence of water, giving rise to an action less energetic, and often more advantageous, than that of the alkaline metals alone. Thus is caused the frequent employment of sodium amalgam for hydrogenizing a large number of bodies. As a consequence of their action on water, the alkaline amalgams are changed by moist air, with production of free alkali or alkaline carbonate.

Applications of Potassium Amalgams.—1. They furnish a process for preparing potassium by the decomposition of potash by the electric current, by employing quicksilver as the cathode, and vaporizing the quicksilver of the amalgam formed by heating this in a current of dry hydrogen.

2. They can serve for the preparation of the amalgams of the metals, other than those of the alkaline group, by decomposing the salts of these metals, with formation of a salt of potash and of the amalgam of the metal corresponding to the original salt.

3. They can be employed as a source of nascent hydrogen in presence of water for hydrogenizing many substances.

Applications of Sodium Amalgams.—These are nearly the same as those of the potassium amalgams, but the sodium amalgams are employed almost exclusively, because sodium is more easy to handle than potassium and is of lower price. These employments are the following:

1. Sodium amalgam furnishes a process for the preparation of sodium when soda is decomposed by means of the electric current, employing quicksilver as the cathode, and afterward vaporizing the quicksilver of the amalgam formed by heating this in a current of dry hydrogen.

2. Amalgams of sodium serve for the preparation of amalgams of the other metals, particularly alkaline earthy metals and metals of high fusing points, by decomposing the salts of these metals, with formation of a salt of soda and of the amalgam of the metal corresponding to the original salt.

3. They serve for amalgamating superficially the metals of high fusing point, called "refractory," such as iron and platinum, when a well-cleaned plate of these metals is immersed in sodium amalgam in presence of water.

4. An amalgam of 2 or 3 per cent of sodium is employed in the processes of extraction of gold by amalgamation. It has the property of rendering quicksilver more brilliant, and consequently more energetic, by acting as a deoxidant on the pellicule of oxide formed on its surface in presence of certain ores, which, by keeping it separated from the particles of gold, destroy its activity. Sodium amalgam of 3 per cent is utilized with success for the amalgamated plates employed in crushers and other apparatus for treating the ores of gold. If a few drops of this amalgam are spread on a plate of copper, of tin, or of zinc, a brilliant coating of an amalgam of tin, copper, or zinc is immediately formed.

5. Amalgams of from 2 to 8 per cent of sodium serve frequently in laboratories for reducing or hydrogenizing organic combinations, without running the risk of a partial destruction of these compounds by too intense action, as may occur by employing free sodium instead of its amalgam.

Application of Barium Amalgams.—These can by distillation furnish barium. It is one of the processes for preparing this metal, which, when thus obtained, almost always retains a little sodium.

Application of Strontium Amalgams.—These amalgams, washed and dried rapidly immediately after their preparation, and then heated to the nascent red in a current of dry hydrogen, yield a fused mass of strontium.

Application of Cadmium Amalgams.—Amalgams of cadmium, formed of equal weights of cadmium and quicksilver, have much power of cohesion and are quite malleable; the case is the same with an amalgam formed of 1 part of cadmium and 2 parts of quicksilver. They are used as dental cements for plugging teeth; for the same purpose an amalgam of 2 parts of quicksilver, 1 part of cadmium, and 2 parts of tin may be used.

Applications of Zinc Amalgams.—The principal employment of zinc amalgams is their use as a cathode or negative electrode in the batteries of Munson, Daniell, and Leclanché. This combination is designed to render the zinc unattackable by the exciting liquid of the battery with open circuit. The action of the mercury is to prevent the zinc from forming a large number of small voltaic elements when foreign bodies are mingled with the metal; in a word, the giving to ordinary zinc the properties of pure zinc, and consequently of causing a great saving in expense.

For amalgamating a zinc plate it is plunged for a few seconds in water in which there is one-sixteenth in volume of sulphuric acid, then rubbing with a copper wire-brush, which has been dipped in the quicksilver. The mercury takes more readily on the zinc when, after the zinc has been cleaned with water sharpened with sulphuric acid, it is moistened with a solution of corrosive sublimate, which is reduced and furnishes a first very thin coat of amalgam, on which the quicksilver is immediately fixed by simple immersion without rubbing.

The zinc of a battery may be amalgamated by putting at the bottom of the compartment containing each element, a little quicksilver in such a way that the zinc touches the liquid. The amalgamation is effected under the influence of the current, but this process applies only on condition that the zinc alone touches the bottom of the vessel containing the quicksilver.

Application of Manganese Amalgams.—These may serve for the preparation of manganese. For this purpose it is sufficient to distill in a current of pure hydrogen. The manganese remains in the form of a grayish powder.

Applications of Tin Amalgams.—1. Tinning of glass. This operation is accomplished in the following manner. On a cast-iron table, quite horizontal, a sheet of tin of the dimensions of the glass is spread out and covered with a layer of quicksilver, 5 or 6 millimeters in thickness. The glass is made to slide on the sheet of tin in such a way as to drive off the excess of quicksilver; when the two surfaces are covered without interposition of air, weights are placed on the glass. In a few days, the glass may be removed, having been covered with an adhering pellicule of amalgam of 4 parts of tin and 1 part of quicksilver.

2. An amalgam consisting of 2 parts of zinc and 1 part tin may be used for covering the cushions of frictional electric machines. This amalgam is prepared by first melting the zinc and tin in a crucible and adding the quicksilver previously heated.

3. I have already spoken of the cadmium amalgam employed for plugging teeth, an amalgam of 2 parts of quicksilver, 2 parts of tin, and 1 part of cadmium. For the same purpose an amalgam of tin, silver and gold is employed.

Applications of Copper Amalgams.—1. An amalgam of 30 per cent of copper has been employed for filling teeth. This use has been abandoned on account of the inconvenience occasioned by the great changeableness of the product.

2. The amalgam of 30 per cent of copper, designated by the name of "metallic mastic," is an excellent cement for repairing objects and utensils of porcelain. For this employment, the broken surfaces are heated to 350 deg. C., and a little of the amalgam, previously heated to the consistency of melted wax, is applied.

3. Copper amalgam, of 30 to 45 per cent of copper, rendered plastic by heating and grinding, may serve for obtaining with slight compression copies of delicate objects, which may, after hardening of the amalgam, be reproduced, either in wax or by galvanic process.

4. According to Debray, when a medal, obtained with an amalgam of 45 per cent of copper, by compression in the soft state, in molds of gutta percha, is heated progressively to redness in an atmosphere of hydrogen, the quicksilver is volatilized gradually, and the particles of copper come together without fusion in such a way as to produce a faithful reproduction, formed exclusively of metallic copper, of the original medal.

5. In the metallurgy of gold the crushers are furnished with amalgamated plates of copper for retaining the gold. The preparation of these plates, which are at least 3.2 millimeters in thickness, is delicate, requiring about two weeks. They are freed from greasy matter by rubbing with ashes, or better with a little sand and caustic soda, or if more rapid action is desired, with a cloth dipped in dilute nitric acid; they are washed with water, then with a solution of potassium cyanide, and finally brushed with a mixture of sal-ammoniac and a little quicksilver, until the surface is completely amalgamated. They are finally made to absorb as much quicksilver as possible. But the plates thus treated are useful for only a few days when they are sufficiently covered with a layer of gold amalgam; in the meantime they occasion loss of time and of gold. So, it is preferable to cover them artificially with a little gold amalgam, which is prepared by dissolving gold in quicksilver. Sometimes the amalgam of gold is replaced by an amalgam of silver, which is readily prepared and more economical.

Another method giving better results consists in silvering copper slabs by the galvanoplastic method, and covering them with a layer of silver of 30 or 35 grammes per square decimeter. Then, it is only necessary to apply a little quicksilver, which adheres quite rapidly, so that they are ready for use almost immediately, and are quite active at the outset.

These amalgamation slabs ought to be cleaned before each operation. Potassium cyanide removes fatty matter, and sal-ammoniac, the oxides of the low metals.

Application of Lead Amalgams.—These meet with an interesting employment for the autogenous soldering of lead. After the surfaces to be soldered have been well cleaned, a layer of lead amalgam is applied. It is afterward sufficient to pass along the line of junction a soldering iron heated to redness, in order that the heat should cause the volatilization of the quicksilver, and that the lead, liberated in a state of fine division, should be melted and cause the adherence of the two surfaces. The only precaution necessary is to avoid breathing the mercurial vapor, which is quite poisonous.

Applications of Bismuth Amalgams.—1. The amalgam formed of 1 part of bismuth and 4 parts of quicksilver will cause the strong adherence of glass. It is employed with advantage in the tinning of glass globes. For this operation it is poured into a dry hot receiver, and then passed over the whole surface of the glass; it solidifies on cooling. For the purpose of economizing the bismuth, of which the price is high, the preceding amalgam is replaced by another composed of 2 parts of quicksilver, 1 part of bismuth, 1 part of lead, and 1 part of tin. The bismuth, broken into small fragments, is added to the tin and lead, previously melted in the crucible, and when the mixture of the three metals becomes fluid, the quicksilver is poured in, while stirring with an iron rod. The impurities floating on the surface are removed, and when the temperature is sufficiently lowered, this amalgam is slowly poured into the vessels to be tinned, which have been previously well cleaned and slightly heated. M. Ditte recommends for the same employment, as a very strong adherent to the glass, an amalgam obtained by dissolving hot 2 parts of bismuth and 1 part of lead in a solution of 1 part of tin in 10 parts of quicksilver. By causing a quantity of this amalgam to move around the inside of a receiver, clean, dry, and slightly heated, the surface will be covered with a thin brilliant layer, which hardens quite rapidly.

For the injection of anatomical pieces, an amalgam formed of 10 parts of quicksilver, 50 parts of bismuth, 31 parts of lead, and 18 parts of tin, fusible at 77.5 deg. and solidifiable at 60 deg. C., is made use of; or again, an amalgam composed of 9 parts of Darcet alloy and 1 part of quicksilver fusible at 53 deg., and pasty at a still lower temperature. This last amalgam may also be used for filling carious teeth. The Darcet alloy, as known, contains 2 parts of bismuth, 1 part of lead, and 1 part of tin, and melts at 93 deg. The addition of 1 part of quicksilver lowers the fusing point to 40 deg.

Applications of Silver Amalgams.—1. In the silvering of mirrors by the Petitjean method, which has almost universally replaced tinning, the property of silver in readily amalgamating is taken advantage of, by submitting the glass after silvering to the action of a dilute solution of double cyanide of mercury and potassium in such a manner as to form an amalgam of white and brilliant silver adhering strongly to the glass. To facilitate the operation and utilize all the silver, while economizing the double cyanide, M. Lenoir has recommended the following: Sprinkle the glass at the time when it is covered with the mercurial solution with very fine zinc powder, which precipitates the quicksilver and regulates the amalgamation.

2. The metallurgy of silver also takes advantage of the property of this metal in combining cold with quicksilver; this for the treatment of poor silver ores.

In the Saxon or Freiberg process for treating silver ores, recourse is had to quicksilver in the state of amalgam in amalgamating casks, in which the ore after grinding is shaken with disks of iron, and with mercury and water. The amalgam, collected and filtered under strong pressure, contains from 30 to 33 per cent of silver. It is distilled, either in cylindrical retorts of cast iron, furnished with an exit tube immersed in the water for condensing the mercurial vapors, or on plates of iron, arranged over each other along a vertical iron stem, supported by a tripod at the bottom of a tank filled with water, and covered with an iron receiver, which is itself surrounded with ignited charcoal. It should be remarked that the last portions of quicksilver in a silver amalgam submitted to distillation are volatilized only under the action of a high and prolonged temperature.

Applications of Gold Amalgams.—1. Gilding with quicksilver. This process of gilding, much employed formerly, is now but little used. It can be applied only to metals slightly fusible and capable of amalgamation, like silver, copper, bronze, and brass. Iron can also be gilded by this method, provided it is previously covered with a coating of copper. To perform this gilding, the surface is well cleaned, and the gold amalgam, consisting of 2 parts of gold and 1 part of quicksilver, prepared as mentioned before, is applied. The piece is afterward heated to about the red, so as to volatilize the mercury. The gold remains, superficially alloyed with the metal, and forms an extremely solid layer of deadened gold, which can be afterward polished. The volatilization should be effected under a chimney having strong draught, in order to avoid the poisonous action of the mercurial vapors.

2. The amalgamation of gold finds its principal applications in the treatment of auriferous ores. The extraction of small spangles of gold scattered in gold-bearing sands, is based on the ready dissolution of gold in quicksilver, and on the formation of an amalgam of solid gold by compression and filtering through a chamois skin, in a state more or less liquid. The spangles of gold are shaken with about their weight of quicksilver, collected in the cavities of sluices and mixed with a small quantity of sand. The gold is dissolved, and the sand remains. The amalgam thus obtained is compressed in a chamois skin, so as to separate the excess of mercury which passes through the pores of the skin; or yet again, it is filtered through a glass funnel having a very slender stem, with almost capillary termination. In both cases, an amalgam of solid gold remains, which is submitted to the action of heat in a crucible or cast iron retort, communicating with a bent iron tube, of which the extremity, surrounded with a cloth immersed in water, is arranged above a receiver half full of water. The quicksilver is vaporized and condensed in the water. The gold remains in the retort.

The property of gold of combining readily with quicksilver is also used in many kinds of amalgamating apparatus for extraction and in the metallurgy of gold.

In various operations, it is essential to keep the quicksilver active by preserving its limpidity. For this purpose, potassium cyanide and ammonium chloride are especially employed; sometimes, wood ashes, carbonate of soda, hyposulphite of soda, nitrate of potash, cupric sulphate, sea salt, and lime; the latter

for precipitating the soluble sulphates proceeding from the decomposition of pyrites.

The amalgamation of gold is favored by a temperature of 38 deg. to 45 deg. C., and still more by the employment of quicksilver in the nascent state. This last property is the base of the Designol process, which consists in treating auriferous or auro-argentiferous ores first ground with sea salt, in revolving cylinders of cast iron with iron and mercury bichloride, in such a way that the mercury precipitated collects the gold, and eventually the silver, more efficaciously.

[Concluded from SUPPLEMENT No. 1563, page 25042.]

SIMPLE STEAM TURBINE ENGINES—II.*

By JOHN RICHARDS.

IT is not unusual, in papers of this kind, to introduce the subject of constructing and operating machines, and it might be out of place in papers relating to some kinds of machines employed in the arts; but, as before pointed out, information on this subject is, at this time, the lacking element in steam-turbine practice.

At the risk of prolixity I will summarize and restate in a compendious way the points already gone over, and then proceed to constructive features.

All fluid machines belong to two classes:

First, machines that receive and translate the force of fluids, or motive engines of all kinds. Second, machines to impel fluids, including pumps of all kinds. This is a division easily understood. Fluids include air, steam, water, gas, all of which come under and are amenable to certain ascertained laws, and are divided into elastic and inelastic fluids.

Fluid motive engines are divisible into two classes—positive and free running. The positive class includes all that operate with pistons and which measure, positively and in proportion to movement, the amount of fluid that passes through them. There is no time factor in positive-acting machines; hence the rate of movement and the work done in a given time are under control. Within certain limits a positive-acting machine may run fast or slow, and its speed can be varied at will. The latter is the most important advantage that positive or piston machines have over the impulsive or non-positive type, and lends itself to a wide field of uses.

This advantage of a variable rate of movement is, however, diminishing all the time, because of the improvement in transmission gearing, designed to change the relative rate of movement.

The free-running class of fluid machines, those which operate by impulse and reaction, have a "time function" to deal with, and their speed is a determinate quantity, based upon the flowing velocity of the impelling or impelled fluid. This class embraces water wheels of all kinds—gravity, impulsive, and reacting; also steam turbines.

The velocity of this impulse class of machines is inversely proportional to the density or weight of the fluids that impel them. A centrifugal pump and a rotary fan seem very different machines, but they operate according to the same law, and their speeds are inversely proportional to the weights of the fluids, or as 800 to 1. This indicates the great velocity at which single-action steam turbines must move, practically about 90,000 feet a minute.

Such a velocity produces various phenomena, such as the disturbance and stretching of the rotative parts by centrifugal strain; tendency to vibrate; noise, the heating and wear of journal bearings, and other things. The centrifugal strain can be imagined when we reflect that one pound of metal on the periphery of a wheel two feet in diameter, will, at a speed of 10,000 revolutions per minute, represent a centrifugal force of 34,000 pounds or 17 tons.

Referring now to the constructive features of steam turbines, the first thing considered will be the buckets, and at the beginning I will claim that these are at

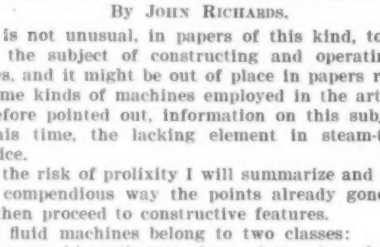


FIG. 5.

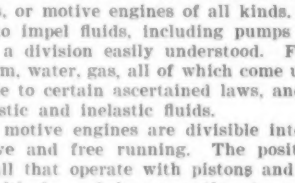


FIG. 6.—EFFECT OF NUMEROUS VANES.

fault in modern practice because of being curved in one plane only; consequently they have but one correct position in the jet throughout the whole arc of their movement and in nearly all cases are cut out of solid metal, and have angular or imperfect corners.

This form of buckets is due no doubt to the difficulty of machining their surfaces except in straight lines, but it produces, in turbine wheels, several features of construction that are far-reaching in effect, also far from apparent until carefully examined.

First. It increases the weight and number of buckets about fivefold in the attempt to secure impingement of the steam jets normal to the straight faces of the buckets.

Second. It distorts the course of reaction from a possible angle of 15 degrees to an angle of 20 to 30 degrees required to secure clearance.

Third. It makes necessary a side application of the jet, introducing lateral stress on the wheels and inducing vibration.

Fourth. It augments, in proportion to the added number of buckets, the amount of fluid friction; not to include the resistance of corners.

Fifth. The disposition of material in solid disks prevents the employment of its fibrous or laminated nature in the direction of strain and demands very expensive homogeneous material, a result indirectly of the numerous buckets.

This is a bold arraignment of certain constructive

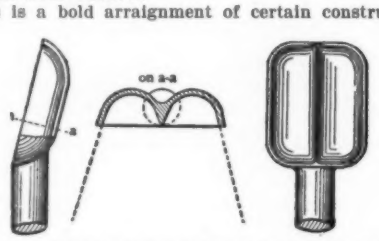


FIG. 9.—FORM OF BUCKET ADAPTED TO A REDUCED NUMBER.

features, and would require great temerity on my part to bring forward were I not fortified by something stronger than inference and personal experience in this matter. I allude to the tangential water-wheel practice on this coast, which has passed through a crucial course of development that furnishes copious suggestion for single-action steam turbines.

The number of buckets is a very important matter. It is a sequence of the angle of impingement, and this again is a sequence of the bucket's shape, as will be shown further on. The surface or fluid friction, which offers a considerable resistance and loss, is in proportion to the number of buckets employed, and should be considered in this connection.

Most of the steam-turbine buckets now made have angular corners, and, when there are not such corners, the end walls of the buckets are so distant from the jet as to lose reactive effect in that direction. We long ago learned to keep water out of sharp corners in buckets.

In respect to the number of buckets or vanes, Fig. 5 shows how the line of impingement varies in respect to the straight faces of radial buckets, being as the sine of the angles *A* and *B;* and there is no way of securing impingement even approximately normal to the straight faces except by employing a large number of buckets set close together. The result is much the same whether the jets be applied on the side or tangentially, as shown in Fig. 6, where the angle of entrance is 20 deg. and that of discharge 36 deg.

The trend of practice in tangential water wheels has been to wider spaces between the buckets, better angles for discharge and recently to uniformly curved buckets, as hereinafter explained.

This feature of oblique impingement is accountable for at least three-fourths of the buckets now employed, and the result is loss by increased surface friction and distortion of the angle of reaction.

Fig. 6 shows approximately the entrance and discharge angles in the De Laval engines, embracing an arc of 56 deg., which, by reducing the number of buckets, could be reduced to 36 deg. or less if the problem of oblique impingement were out of the way. Fig. 7 shows spacing for tangential buckets to secure an easy discharge at 20 deg.

In the Riedler turbines, the angle of discharge is 180 deg. In other words, the discharge is opposite the jet, but this calls for increased surface, more width and weight for the revolving member, and expensive work in construction, which are hardly offset by countervailing advantages, and which certainly prevent a cheap and general manufacture of the machines. It would not be becoming in myself to criticise the computations and designs of Prof. Riedler, but I am looking at the practical and mechanical phases of the problem, and seeking means whereby such engines may be made at a reasonable cost by common facilities and operate at reasonable efficiency.

The contention is that the buckets of steam turbines should be curved in all planes approximately as shown in Fig. 8, taken from a form of water buckets of a very advanced type by W. A. Doble, of this city. These are of double concave or cup form, in order to permit direct and balanced impingement at the various angles in which they are presented to the jet, and have a central dividing wedge to permit tangential application. This latter is not presented as a new idea, being simply the final form and method for tangential water wheels on this coast, after more than twenty-five years of continuous experiment and the attainment of an efficiency that is, if not final, so nearly so that a very narrow margin of avoidable losses remains.

If there exists any reason why this same system or method of operating is not applicable to buckets for steam, I am not able to perceive it. Of course, expansion of the steam and divergence of the jets would call for modification not determinable until a form of nozzle and the contour of the jet are assumed.

Not knowing how far the contour of a jet of steam will permit its passage through notch *A*, in Fig. 8, I am not able to say how far this feature is applicable to an elastic fluid, or how far such a passage as that at *A* would become a spillway when a jet was impinging at the opposite end of the bucket. I will not discuss this here, further than to point out that this passage *A* avoids passing the rim *B* of the bucket through the jet and the disturbance that must result from this cause.

The dividing wedge, *C*, permits tangential application of the fluid and produces a shallow and balanced discharge. As a feature of impulse-fluid motors, it has not met with analysis and adoption except on this coast and in the Riedler steam turbines. Its function, or rather its effect, is not always understood. The avoidance of side stress on wheels, especially on steam turbines at their enormous speed, is important, and so is the dual discharge which permits a more nearly uniform velocity throughout the discharged water section, because the latter is shallower. After many years of practical experiment, as well as some spent in scientific work, the dividing wedge was confirmed at the University of California in 1883* as a permanent feature of good practice for water.

In Fig. 9 is shown a form for buckets capable of receiving and properly reversing a jet of steam coming within angles *A* and *B*, and permitting the number of buckets to be reduced to what will come within and cover the divergence or expansion of the steam jet, or about one bucket for each 8 deg. of arc for wheels from 20 to 40 inches diameter. This is less than one-fifth the number now employed for wheels having buckets straight in one plane as in Fig. 6.

Such buckets can be stamped out of fine steel and made strong, smooth, and integral with their radial supporting stems. They can be made of uniform thickness, with no more metal than their operative functions require, and of less than half the weight of those cut from solid metal, so that, compared with the usual form of steam turbines, there would be one-fifth the number and (excluding the fastenings) less than one-half the weight, so that the mass in the rim of a turbine wheel with this form of buckets can be reduced to one-eighth or even one-tenth of that in common practice.

In the construction to be hereafter suggested, the buckets represent and constitute the whole rim of a wheel.

As to wheels or disks, nearly all now in use for single-action engines are solid disks, as shown in Fig. 10, a matter much to be wondered at if we consider the strains. Not everyone has had the opportunity of seeing disks at high revolution, circular saws, for example, which, at a speed of 10,000 feet per minute, assume a sinuous path at their peripheries and lose their stability by stretching.

A bucket, weighing an ounce, and revolving in a circle 24 inches in diameter at the rate of 10,000 revolutions per minute, will exert a centrifugal strain of one ton, and its supporting sector and fastenings will exert 50 per cent more—a result scarcely conceivable. The disposition of mass, strains and section may mathematically produce a body of the spindle form shown in Fig. 10 and in all diagrams that have been worked out by computation, but I do not believe that practical experiment will evolve anything of this kind.

Assuming this centrifugal force applied to a sector of a solid disk of uniform section, a circular-saw plate, for example, the error of such construction becomes apparent. The disposition of the material, in a sector of the wheel of which the bucket is the outer end, will be inverted, so to speak, and disposed inversely as the strain. The perimeter has no function requiring a continuous mass there, unless it be to hold a series of buckets set close together or to provide mechanical fastenings for them.

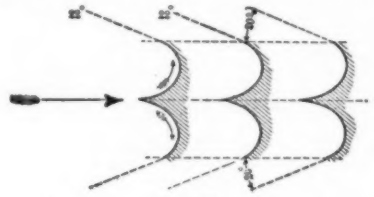


FIG. 7.

FIG. 8.—BUCKETS CURVED IN ALL PLANES.

To compensate this contradictory disposition of material, the wheels are commonly made in lenticular form, as shown in Fig. 10, so that the mass of a sector is approximately a radial body of nearly equal section.

* Read before the Technical Society of the Pacific Coast.

* Partial Turbines or Tangential Water Wheels. College of Mechanics, Berkeley, Cal. By Ross E. Browne.

apparently providing for centrifugal strain if change by elongation is ignored; but this latter is the principal fact and one which cannot be provided for in a solid disk of any form, because the conditions are not ascertainable. I have made diagrams to show the mass, in 10 deg. of arc, for several forms of wheels, but want of space prevents their reproduction here.

I have had made, by a very competent engineer, an analysis of the strains in several forms of solid disks, independent of elasticity and of change by stretching, a condition that defies computation in metal forms of the kind. It is an interesting, and also an intricate problem, but I believe of but little practical value.

A very extensive analysis of such disks or wheels, made by Frank Foster, was published in The Engineer, London, No. 2506, January 8, of the present year. It is a study in mathematics of a very abstruse and no doubt interesting nature to students in calculus, but the weight and cost of such disks, if there were no other reasons, preclude their use for plain simple engines, such as those to which these remarks are directed. Prof. Riedler seems to disregard such theories respecting the disposition of material in his disks.

I have shown how four-fifths or more of the weight in the periphery or rim of such wheels can be dispensed with, and I will suggest for the body of the wheels a construction which will eliminate inherent strains due to elongation or stretching, and at the same time dispense with the greater part of the mass and reduce the centrifugal strain accordingly.

In wheels moving at such high velocity, certainly the first thing should be to remove from the disruptive zone all joints and mechanical fastenings. These must necessarily include an extra mass of inert material at the points of juncture, plus bolts, rivets or other means of attachment. Buckets or other parts fastened by dovetail joints are open to the same objection, because extra substance must be added to endure compression and holding strain.

The construction shown in Figs. 11 and 12 is suggested, the buckets being made independent, avoiding circumferential strain and permitting free elongation by centrifugal stress. The spokes *B* are tapered, so that their sections will stand the centrifugal strain within the mass lying outside of any point. They are fastened in a nave by welding or by suitable mechanical means, the strength of which will equal their section.

The nave of the form shown in the diagram will not expand and become loose on a spindle with the amount of weight in a wheel constructed as shown.

In respect to gearing for transmission, I believe that the principal impediment is a want of confidence. Nowhere in the arts have we been called upon for translation at such high velocity; consequently we are not prepared to provide devices such as are required to reduce the speed of single-action steam turbines, where the elements of transmission have to move from 4,000 to 6,000 feet per minute. I know of no reason why plain tooth wheels, or tangent gearing, will not run at this speed, and I confidently expect that they will do so without any objectionable result.

Respecting tooth gearing there is much apprehension, which arises from the difficulties of constructing it in perfect form. In the Continental Hotel in Philadelphia a screw elevator was in use for more than twenty years. A bevel wheel of 5 feet diameter and a pinion of 10 inches diameter drove the screw, and they were absolutely noiseless. They were made at the Industrial Works in that city, where I was working at that time.

In an experiment made many years ago, at the works of William Sellers & Co., to test the ultimate speed of transmitting apparatus, bands of one kind or another were employed up to a point of failure, then plain spur wheels were resorted to, and, as I have been informed, they were entirely successful to the point of disrupting a steel disk driven by the gearing. Of course, such gearing to run without noise must be perfectly made; and, if there is reason why they will not transmit at 4,000 to 6,000 feet per minute, I fail to conceive it, especially when inclosed in the turbine wheel chamber, as hereafter suggested.

Twenty-five years ago I constructed machines in which bands of flax webbing ran at 6,000 feet per minute without difficulty.

These bands drove spindles at 12,000 feet per minute, and the machines are yet in use in Columbus, Ohio, where they were made in what might be called a country shop.

For a good many years I was engaged in designing and making machines in which the spindle bearings had a velocity of from 2,000 to 3,000 feet per minute, were subject to lateral strain and mounted in weak framing, and they ran cool when the fit and alinement were good. Consequently I am in no way alarmed at the requirements in steam-turbine practice, and I confidently expect to see power transmitted by bearings moving at a surface velocity of 5000 feet per minute and spindles run cool at 10,000 to 15,000 revolutions per minute.

In my opinion the gearing of transmission should be inclosed with the motor wheel, and should operate in the vapor contained in the casing, that being open to a condenser. There are three reasons for this: (1) The better performance and wear of wheels when steam lubricated; (2) the absorption of noise, if that be present; and (3) the avoidance of packing glands

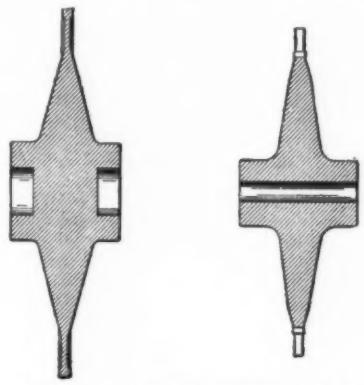


FIG. 10.—SECTION OF WHEEL.

on the spindle of the motor wheel, a very objectionable feature, present, I believe, in all the steam turbines now made.

Such packing glands are objectionable not only because of a possible resistance and loss of power by friction, as pointed out by Prof. Sweet, but because they permit the entrance of air into the condenser and involve the wear and care of packing.

The interior of the wheel casing should be annular, turned smooth and otherwise so arranged as to permit the free revolution of any vapor it may contain. It has been suggested that a sector or spoke construction of the wheels would cause serious resistance by windage or fanning the steam or vapor in the casing; but the attenuated vapor in a casing, 10 to 12 pounds below the atmosphere, would not offer much resistance if fixed, and perhaps none to consider at all, if free to revolve with the wheel.

In respect to bearings for the wheel spindle, these should be parallel, hardened and ground, mounted in pivoted split shells of gray iron, and, like the reducing gearing, inclosed in and exposed to the vapor of the wheel chamber. This may seem objectionable because of heat, and it would be so in machines as now arranged, with the casing exposed to a high temperature.

This latter I believe to be a mistake. No avoidable heat should be communicated to the casing to raise its temperature above that of the expanded steam. A low temperature would not cause appreciable thermal loss in the jet, but would assist a condenser and conduce to other desirable objects that have been named.

In respect to nozzles for buckets, such as have been suggested, it is a difficult subject without experiment and when the contour of a jet at different pressures is not known. I am of the opinion, however, that if inclosed the tube should conform to the natural contour of the jet. With side application of the steam on buckets flat or straight in one plane, there is no doubt a gain results from the use of a diverging nozzle, but in buckets in which the jet is divided the case is different.

On the whole, I think it safe to assume that the form of nozzles for steam turbines of the single-acting type is not a problem that will much interfere with their successful construction. That there should be a converging anterior chamber, a throat to determine volume and a diverging nozzle is obvious, but further than this the result is no doubt a refinement that has more importance in a mathematical theorem than in the workshop.

Some years ago, I think in 1901, I asked Mr. Brown, whom I have several times quoted, his opinion respecting steam-motor nozzles. He replied as follows:

"As regards the De Laval nozzles, the learned here are of various opinions as to their value. Prof. Meyer, in Zurich, who has experimented long with the De Laval, says that it is in no way superior to a common nozzle."

The views and suggestions which I have had the privilege of advancing here have been imperfectly embodied in an organized mechanism, shown in Fig. 13. This drawing was made about two years ago, and it would be modified in various ways if reproduced now. It, however, embodies most of the features that have been suggested.

I presume this presentation of a subject, without the scientific furtherance common at this day, can hardly be considered a conventional contribution to the art. It may not be so accepted, but I venture the prediction that the evolution of cheap steam turbines, adapted for general manufacture and use, will before long result from effort and experiment on the part of intelligent and experienced mechanics aided by scientific data.

This assumption has some answer in the fact that, already mentioned, seventy-five years ago Mr. Avery, a country millwright in western New York, made successful reaction steam turbines, and applied a large number of them successfully to common rough uses. He also made impelling members which contained about one-tenth of the material now employed, and, as I believe, in a more practical manner than in many wheels now being produced. The work was done in blacksmith shops, at a time when accurate tools and processes were almost unknown, and I am much inclined to agree with the opinions of Prof. John E. Sweet, whose skill and judgment no one is likely to question, who, in a recent letter to the author, said: "If I were to engage in the manufacture of steam turbines I would begin with the Avery one."

The steam-turbine practice of our day is the finest example of constructive engineering work that the world has ever seen. It is confined to large units, not because of operative impediments in small engines, but because these cannot be furnished separately at such prices as can be obtained.

From these premises I conclude that future steam turbines for common use will be single-acting and condensing whenever possible, with wheels of sector construction as light as can be made. There will be no packing glands on the main spindles, and the first movers for transmission will be plain spur or tangent gearing.

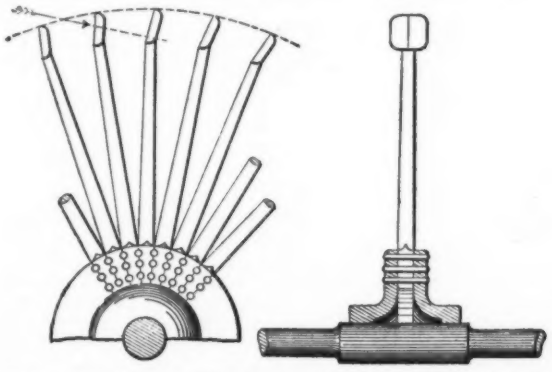
I will conclude this paper with brief mention of the economic results that have been reached with steam turbines, as illustrated by the generating engines recently constructed in Switzerland, one with very high-class piston engines and one with turbines, each of 5,000 horse-power. The results were as follows:

Weight of piston engines and generators, 598 tons. That of the turbines and generator only 78 tons, or nearly 8 to 1. The steam consumption by the piston engines was 11 pounds per indicated horse-power, and for the turbines 1 kilowatt with 14 pounds of steam, or about 10 pounds per horse-power. Oil consumption was as 20 to 1 in favor of the turbine, and attendance about 5 to 1.

The piston engines were made by Sulzer Bros., of Winterthur, and the turbines by Brown, Boveri & Co., of Baden, in Switzerland. The quantities were furnished to me by Mr. Brown, of Basel, Switzerland, with whom I had personally discussed the subject some time before the tests were made and who had forecast the result with much accuracy.

WOOD DISTILLATION.

Wood distillation has been tried in this country so extensively of late, and has been brought so promi-



FIGS. 11 AND 12.—TURBINES WITH REDUCED NUMBER OF BUCKETS.

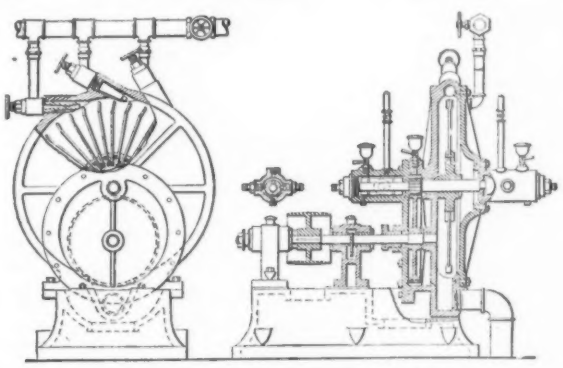


FIG. 13.—THE COMPLETE MACHINE.

nently to the attention of the Forest Service as a means of utilizing waste in lumbering, that a careful and thorough investigation is to be made by the service, covering both what has been accomplished in this industry and what may be done to reduce it to more scientific principles and to place it upon a sound commercial basis. The various processes now in use will be studied and compared, as well as the resulting products, and the uses to which they are or may be put.

To push this study to early and useful results with the least possible delay, Thomas W. Pritchard, a practical expert in wood distillation, has been engaged by the Forest Service to devote his entire time to the

work. Mr. Pritchard, who is a trained chemist, has for several years been connected with distillation plants in the South. He has already begun his work with the Forest Service, and will at once communicate with the owners of wood-distillation plants throughout the country to determine the degree of success to which the business has reached. He will then closely examine the methods which have resulted most successfully, and attempt to extend their use. He will pay particular attention to the extent to which lumbermen may adopt wood distillation as a means of turning into useful products the tops, slabs, and other waste of sawmills, which are often at present a total loss.

Destructive distillation consists in driving out all the liquid matters in the wood and collecting and condensing them afterward. Intense heat is employed, and the original form of the wood is changed chemically into various liquids and pure carbon. The wood is closely placed in a steel retort, with the doors tightly sealed, and fires are started in the furnace beneath. In a few hours distillation begins. The liquids are driven from the wood, are changed to vapors, and pass off through a pipe at the top of the retort, which leads to a condenser or worm, immersed in water, where they are condensed in the order of their gravity. Again restored to liquid form, they then pass through the rest of the coil and run intto collecting tanks. The gas rises to the top of the coil and is piped off. The liquid products are redistilled in a secondary still into the various oils and by-products.

REINFORCED CONCRETE CONSTRUCTION.*

By LEWIS A. HICKS, Mem. Tech. Soc. Pac. Coast.

THE West, usually first to devise and adopt improved methods, has been slow to apprehend the merits of reinforced concrete, and even when engineers and architects are converts to its advantages, the difficulty in securing intelligent execution of work by reliable contractors, and the lack of standards, both as to specifications and practical methods, has retarded and prevented its use. The fact that it has been largely exploited in this country in conjunction with patented systems of floor construction has also operated to its detriment, for it has been very commonly the case that the commercial licensees of the various systems are not well informed as to the principles of design, and in their efforts to demonstrate the superiority of their own methods have made unwarranted claims which have not tended to establish the material in its proper place in the eyes of intelligent constructors.

Definite information is now available from actual tests in our college laboratories that give us sufficient data to examine the general relations of stress and strain in transverse bending and the application of the simple fundamental principles that obtain with other structural materials are found to furnish rational solution for its problems.

The greatly extended use of reinforced concrete which has resulted from the rationalizing of its design data is amply in evidence from the many illustrations of its construction in the technical press, and from the flood of descriptive matter concerning it.

When the elementary principles of its correct design are within the knowledge of the engineering fraternity, and its phenomena of distortion under stress are known to be reliably reproducible, no argument is required to convince one of its prime importance in the list of materials available for engineering construction.

The factors combining to this result are economy in time and money due to the existence of the great bulk of materials where required as raw products; the possibility of assembling these materials with unskilled labor, by the use of machinery insuring uniform results; the supplementing of defects in the structural character of concrete by the use of small quantities of steel in the form of commercial shapes, everywhere available from stock; the substitution in many places of members of light sectional area, capable of withstanding known stresses to which they may be subjected, in place of heavier gravity sections required for other materials; its high value in fire-resisting and time-endurance characteristics, and, finally, the facility with which it may be adapted to the needs of rapid construction under intelligent, systematic organization.

Most of you will concede its usefulness for dead loads in warehouse, power house and other heavy construction. The latest expert testimony as to its fitness for live loads under the severe conditions of railway traffic is furnished by the report of the committee of the International Railway Congress at Washington, which finds favorably to its use for railway bridge work.

Weak design in this class of work, involving not only economic loss but the safety of human life, would be criminal, and the deliberate judgment of these experts should receive the consideration which their experience warrants.

The question at once suggests itself as to how far this conclusion can be applied to the construction of high buildings, where the conditions both as to property values and the responsibility for life are probably more acute than in bridge work. Here many of you will be dubious as to whether structural steel can be safely replaced with reinforced concrete, and those most familiar with building operations will be openly skeptical.

To examine briefly such data as may be available pertaining to the design of reinforced concrete cage construction is the purpose of this paper.

We will pass over the subject of foundation design, inasmuch as tension bars have already commenced to replace structural steel, by reason of the saving of time and depths, and because the data used for transverse bending stresses in the design for girders, beams and floor slabs, considered later, may be adapted to foundation work.

The next element to be considered in building work is naturally the design of columns and the economic statement of the problem is whether we can, without loss of valuable floor space, substitute for steel, which under building conditions carries safe concentric loads of 12,000 pounds per square inch of sectional area, a combination of steel and concrete with a relatively low value of compressive resistance.

The best information available in the literature of the subject has its origin in the work of Considere, but its statement, like that of his conclusion regarding the increase of ductility of concrete by addition of steel, is paradoxical and misleading.

American experimenters have shown that the apparent increase of stretching power in tension members, which Considere regards as an actual change in the elastic characteristics of the concrete, is merely the distribution of the cracks present over the entire length of the members under stress, so that the total stretch is so subdivided that the cracks are invisible within working limits.

In the same way, the conclusions of Considere on the reinforcement of columns do not offer a complete analysis of the phenomena observed. Summarized, his conclusion is that ultimate column resistance will consist of the sum of the compressive resistance of the concrete, within the windings; the proportionate elastic compressive resistance of the vertical reinforcement and the resistance afforded by the spiral windings, considered by him to be equivalent to 2.4 times as much as would result from the use of the same amount of metal if placed as vertical reinforcement. He also claims that conditions of maximum efficiency exist when pitch of winding is from 1-7 to 1-10 of diameters of winding.

Actual designs range from 2 to 4 per cent reinforcement, used in hooping or winding, and from 1 to 3 per cent in verticals, the percentages referring to volume of concrete inside the reinforcement. Using mean values of 3 per cent for hooping and 2 per cent for verticals, with a factor of safety of 3.5, recommended by Considere, safe load values of 1,000 pounds per square inch result.

When this loading value is applied to design of column for heavy loads in high building construction it will be found that while an economy of cost amounting to 25 to 35 per cent of steel column costs may be secured it will be at the expense of loss of floor space. If the earning power of the floor space so lost is capitalized and added to the first cost of the concrete column it will appear that the economic cost of the concrete column is twice that of a steel column performing the same duty.

It follows as a rough approximation for heavy loads that safe load values of 2,000 pounds per square inch must be realized before concrete columns can be regarded as economically superior to steel. Substantially the same floor space would then be required for both types of columns, and as the first cost of the concrete column would not exceed 50 per cent that of steel, it is evident that this difference would in time overcome any existing prejudice in favor of steel.

In the minds of many engineers not personally familiar with the actual use of reinforced concrete there would be grave doubt as to the propriety of using as a safe load value such a high figure as 1,000 pounds per square inch, and this doubt is reflected in the ordinances which have been adopted by several of our American cities regulating the construction of reinforced concrete. The Cleveland building ordinance, adopted only last year, is, generally speaking, a notable improvement on the ordinances in force elsewhere.

Its provisions relating to concrete columns permit vertical steel members, tied or riveted together, to be filled and surrounded with concrete with an assumed division of stress between the concrete and steel, but finally begs the whole question by requiring that the steel itself, standing free, shall be capable of carrying the entire load, with a factor of safety of three when figured as a latticed column.

It is a common thing in construction work, illustrated in our engineering press, to see hooping spaced from one to two diameters apart and without evidence of design with regard to the work to be performed.

All of these considerations indicate that present practice does not warrant such unit loadings as would tend to extend the use of reinforced concrete to column construction in high buildings and we may conclude that unless some further improvement is made in the combinations of the materials there is no danger that the general use of structural steel in this field will be affected.

The writer is not content to accept this as a final conclusion without further investigation, and believes that there are possibilities suggested by the experiments of Considere which give promise of much better results. Some of the prisms of hooped concrete noted by him developed a compressive resistance of 10,500 pounds before ultimate failure, and the character of the failure is not noted.

Some months ago a general outline of some experimental work on full-sized columns was agreed upon with Loren E. Hunt, testing engineer for the University of California, which has a testing machine with a range of 200,000 pounds.

Some delay occurred in making up the test specimens, and it was not until May 10 that the concrete filling was placed. We had expected to test them about June 10, so that the results would be available for this paper, but unfortunately the absence of Mr. Hunt for the summer, and the fact that the testing machine was in need of repairs, have entirely frustrated the object in view. If this could have been foreseen the writer would not have undertaken a paper at this time, but, inasmuch as it had already been programmed, it has seemed the better apology to give you the reasons which have influenced the undertaking of the experiments.

It is also hoped that any discussion evoked may serve to modify favorably the form taken by the experiments by bringing some new light to the problem.

The phenomena of the molecular resistance to displacement offered by the various substances used in engineering work are but imperfectly understood, and the conventional stress strain assumptions often fail to express all the facts.

As examples of isolated facts, there may be instanced the fatigue of material; the raising of the elastic limit of steel bars by torsion or reduction of sectional area involving additional molecular displacement, without apparent change in ultimate resistance, and the similar increase of the modulus of elasticity for compression in concrete under successive loadings, well established by a number of observers.

Relatively little attention has been paid by investigators to the lateral distortion suffered by materials under compressive stress involving change of volume, and very little information is available regarding such deformation in other than true ductile materials.

In the test of any material where failure occurs without flexure by pure compression, diagonal shearing forces are produced which tend to cause the molecular structure to distort laterally by the sliding past one another of the particles.

In the case of metals which under ultimate stresses bulge all around normal to the pressure, failure is by convention conceived to have taken place when a stated percentage of distortion in length has been produced, but with natural stones, which are notably weak in shearing and tensile values, actual failure occurs primarily by the spawling out of material in triangular shapes normal on all sides to the axis of pressure followed by actual crushing due to reduction of resisting area and consequent increase of unit pressures. Concrete exhibits the same characteristics as the natural stones. Brick piers also fail by lateral bulging, accompanied by longitudinal shear, which is probably the real cause of failure in all non-ductile materials.

It is evident that before failure occurs in a non-ductile material there must be some elastic distortion laterally, and that the strain so produced by a vertical stress may be measured and stated, within the elastic limit, as a definite ratio of the vertical strain produced —within the same limit. It follows that the horizontal stress must be in the same ratio to the vertical stress.

In the case of gases and fluids under pressure there is perfect freedom of molecular displacement, and the full pressure is transmitted laterally to the containing receptacle.

With solids, a portion of the pressure is consumed in overcoming what Considere has termed the specific resistance of the material under test, and only a fraction of the pressure reaches the containing receptacle laterally, or is present as stress to produce lateral spawling. It seems probable that in a material of relatively low density, like sandstone or concrete, a vertical readjustment might take place without transmitting as large a transverse pressure as would be the case with such a material as steel.

A tabulation of the value of the ratio between vertical and lateral strains for building stones is given by William H. Burr, without a statement as to its derivation. Its value varies from 1-11 for certain Oregon sandstone to ¼ for marble and granite. Steel is stated to have a ratio of 1-2.35. To determine this ratio for concrete is the primary purpose of the proposed experiments.

It was found by Considere in his earlier work that failure of hooped concrete always occurred by bulging of the concrete between the spirals. The pitch of the winding was therefore decreased, and verticals were introduced to further break up the lateral yielding.

If the resistance moment of the verticals to internal bulging is in excess of the tensile strength of the winding, failure occurs by the breaking of the winding and the simultaneous bending outward of the verticals and characteristic spawling and crushing of the concrete.

Such failure under known conditions as to vertical loading and elastic limit of the winding evidently furnishes the data to determine the ratio of lateral strains in concrete at the moment of rupture.

An experiment made by R. F. Dunn is described by Charles F. Marsh in his work on Reinforced Concrete, which indicated internal lateral bursting pressures of about 1-15 of the vertical pressure applied at the ultimate strength of the winding, as determined by independent tensile tests.

This is the only test of the kind within the writer's knowledge where all the conditions are known, and does not, of course, furnish sufficient evidence to warrant the use of this ratio as applicable to concrete generally; neither does it inform us as to whether the ratio is maintained under changing load conditions.

Imagine a steel pipe with walls of such thickness that its distortion, under internal pressure within a stated range, would be negligible. Suppose another smaller pipe, of 2 inches less diameter, made of the same material except for the center joint, is inserted within the larger pipe and connected at either end so that the outer pipe forms an annular water-tight

* A paper read before the Electrical Transmission Section of the Pacific Coast Engineering Congress, held at the "American [illegible] the auspices of the Lewis and Clark Centennial Exposition, P[illegible]

jacket. Let the center joint in the smaller pipe be made of very thin sheet steel and fill the small pipe with concrete, first filling the annular jacket with water under a slight pressure to prevent the tamping of the concrete from distorting the thin sheet steel portion. Permit the concrete to set, fill the outer jacket with water under a slight pressure to insure perfect contact, connect a pressure gage to the jacket and submit the concrete inside the small pipe to endwise compression. Then will the resistance of the outer pipe, acting through the water and the thin sheet metal, prevent the lateral distortion of the concrete, and the gage will record the internal pressures transmitted to the outer pipe shell by the water. It would thus be possible to observe the lateral thrust of the concrete for any given vertical pressure within the range of the apparatus.

With this bursting pressure as a known ratio of the unit load to be carried by a column, it is evidently possible to design a pipe of the right diameter to provide the proper sectional area of concrete inside for the unit pressure allowed, and of such thickness as to furnish safe resistance to the lateral thrust, utilizing the usual hydraulic pipe formula.

Mr. Hunt has suggested the testing of such a column, designed with a very small safety factor in the steel, by surrounding it with a water jacket provided with a glass manometer tube of small caliber so that the lateral enlargement under changing loads may be shown visually by the raising of the water in the tube and the displacement, together with the observed shortening of the column endwise, would determine the actual change of volume. Several specimens having diameters of 4, 6, 8 and 10 inches and lengths of 132 inches have been prepared, with a steel reinforcement of riveted hydraulic pipe designed for a factor of safety of 5 in the plate, from the simple relation $t = r/100$, which if reduced for rivet inefficiency probably involves an actual safety of 3 against a vertical working stress of 2,000 pounds per square inch. The concrete filling is a mixture of 1-2-5 of California cement with Presidio beach sand having 40 per cent voids, and Niles roof gravel of from ¼ to ½ inch diameter and voids of 30 per cent. The ratio of length to diameter varies from 13 to 33, and as no provision for flexure was made, some of the columns will undoubtedly fail in that manner.

The introduction of symmetrically placed vertical bars against the pipe wall on the inside will evidently take care of bending moments induced by flexure or eccentric loading, and will also serve to distribute any local tendency to internal shear. For ordinary building story heights this would not be required.

The writer questions whether the addition of vertical reinforcement without hooping really adds to the effective strength of concrete columns; for, inasmuch as the failure of the concrete has been shown to be in longitudinal shear, and the steel bars have no transverse bending strength, it seems apparent that the critical point would be the lateral yielding of the concrete from shear parallel to the axis of pressure. Believing this, the writer regrets that such a doubtful method of reinforcement has been adopted by Considere as the measure of value of so reliable a material as hooped concrete. On the other hand, if lateral yielding is prevented and the ratio of length to diameter is within flexure limits, and the modulus of elasticity within the reinforcement is increased by successive loadings until it approximates that of granite, there appears to be no other limit to the compressive resistance of the column than the final bursting of the reinforcement. It seems probable that the ratio of lateral to vertical strain may increase as the modulus of elasticity increases, so that the bursting pressure will not continue in the same proportion to the loading, and a limit may be reached much sooner than would be indicated if the Dunn ratio were a constant; but in any case the placing of the limit is evidently within the power of the designer when experiments have determined the actual behavior of the material under such conditions.

The theoretical and practical advantages afforded by the suggested form of reinforcement offer strong arguments in its favor. Inasmuch as the concrete outside the hooping has no structural value other than fireproofing, it is evidently not important that the concrete within and without the reinforcement should be connected. Fireproofing may be applied to pipe reinforcement, with light wire hoops to prevent crackling, in the same manner as to ordinary steel columns, either at the time of construction or afterward.

One of the common methods employed in building spirally wound columns has been to assemble the component parts for a story height in the shop, placing the vertical bars symmetrically in the winding, and tying them together thoroughly, so as to permit transportation and placing without disarrangement. Part of the verticals extend through above the floor level to anchor the next additional length, and four of the rods are commonly bent out at right angles to anchor the beams and girders intersecting at the column. Because of the bending down of these rods the winding usually extends from the floor to the ceiling line only, where the bending commences, and the concrete intervening between that point and the next floor line lacks continuous protection against lateral and vertical loading of 1,000 pounds per square inch by the column within the reinforcement.

It is then in much the same condition as if a loaded column were placed directly on a concrete pier, without a shoe or base.

In the case of a pipe column, continuous protection is secured from the shoe on which it rests to the highest roof load imposed. At junction points the tension and shear rods of the girders and beams would be slotted through the continuous pipe, with a loose hoop placed outside the pipe, both below and above the point slotted, to make up for the strength lost in the pipe.

Reinforced concrete beams as usually designed have a sufficient area of steel in the tension bars to provide for vertical shear without considering the concrete, but where this is not the case short shear rods may be inserted through the column walls to support the beams with loose hoops as above described.

It is apparent that the placing of the reinforcement as a pipe greatly simplifies and expedites the work of construction when compared with the handling of a mass of spiral winding which has every chance of displacement from its proper position at the hands of the tamper.

Assuming the correctness of the Dunn ratio, the percentage of steel required for safe loading of 2,000 pounds per square inch in the form of riveted pipe would be only 2 per cent of the volume of concrete, as against 3 to 6 per cent recommended by Considere for spirals and longitudinals.

The considerations discussed contemplate only the use of the concrete within the reinforcement for compressive resistance and dependence on a thin exterior steel pipe in tension only for transverse internal stresses. There is a further possibility of reducing sectional area of columns for extreme cases by increasing the thickness of pipe wall and loading it in compression as well as the concrete, but the writer feels that it is useless to go further at present than to suggest lines for investigation and experiment which seem to warrant hope of practical results.

The determination of the modulus of elasticity for concrete by experimenters has so strongly reflected the uncertainties of the personal equation involved in mixing and other variables, as shown in resulting values of from 1,500,000 to 7,000,000 inch-pounds, that there is some natural hesitation in applying the results obtained to actual designs where the equation of the man with a shovel is introduced and mathematical refinement of treatment is evidently out of place.

(To be continued.)

CANADIAN ROUGH CASTING.

ROUGH casting, or, as it is sometimes called, slap dashing, both of which are synonymous with the French *hourdage*, rough work, and *ravalement*, having a similar meaning, is a method of plastering the outside of buildings much used in the northern part of Canada because of its being durable, cheap, and well adapted to keep out cold winds during the long winters in that section of the world. The methods of applying rough cast and the mixing thereof do not materially differ from the methods adopted in Northern Europe or even in the Northwestern States, but it is these minor differences, says a writer in an exchange, that make the Canadian rough casting superior, so far as durability is concerned, to much that is done in other parts of the world.

There are frame cottages near the city of Toronto and along the northern shores of Lake Ontario that were plastered and rough casted exteriorly over 40 years ago, and the mortar to-day is as good and sound as when first put on, and it looks as though it was good for many years yet if the timbers of the building it preserves remain good. Rough cast buildings are plentiful in every province in the Dominion from Halifax to Vancouver and from Lake Erie to Hudson Bay, and when well built, and the rough cast properly mixed and properly applied, the result is always satisfactory. It is quite a common occurrence in Manitoba and the Northwest Territories in the winter to find the mercury frozen, yet this intensity of frost does not seem to affect the rough casting in the least, though it will chip bricks, contract and expand timber, and render stone as brittle as glass in many cases, and the effect on iron and steel is such as may prove dangerous if exposed to sudden and unexpected strain.

In preparing a frame or log building for rough casting, care must be taken in putting down the foundation. A good stone or brick foundation is, of course, the best, but where rough casting is intended, stone or brick foundations are seldom used because of their cost, and the builder is compelled to use posts of wood. The posts are generally made of white cedar, which has a lasting quality of 35 or 40 years if sound when used. The posts are put in the ground from three to five feet, the deeper the better, as they should be deep enough in any case to prevent frost from forcing them upward. When a sufficient number of posts have been properly placed, a line is struck on them the proper height from the ground and the tops leveled off. The sills are then placed—all joints being broken on top of posts—and the whole made level. These sills and all the other timber, scantlings and lumber should be well seasoned, if possible, for the greatest enemy to the plasterer is unseasoned timber; shrinkage of joists, posts and scantling not only breaks the bond of the mortar, but causes great cracks in corners and angles that no amount of pointing or patching can ever make good.

When the frame is up and the rafters on and well secured the whole of the outside should be covered with good, sound, common inch stock pine, hemlock, spruce, or other suitable lumber, dressed to a thickness. If put on diagonally so much the better, but this is not absolutely necessary if the rough casting is to be of the best quality, as will appear hereafter.

When it can be done it is best to get all partitions set in place and lathed, the roof on and all necessary outside finish or grounds put in place and made ready to receive the lath. The carpenter must prepare his finish or grounds for finish to accommodate the extra lath, as the walls will be thickened accordingly.

For the cheaper sort of rough casting in one or two coats the following method of lathing is employed: Nail laths on the boarding—over paper or felt, if paper or felt is used—perpendicularly 16 inches from center to center if 4-foot laths are used, or 18 inches or one foot from center to center if 3-foot laths are used. The whole surface to be rough casted will require lathing this way. When done lath as is ordinarily done with No. 1 pine lath, breaking joints every 15 inches. Put five nails in each lath, driving each nail home solid, coat over with mortar, well haired, and that has been made four or more days; smooth and straighten as well as possible with a darby. When done and while yet soft the rough cast is thrown on it with such force as to drive the pebbles or small stones deep into it. The mixture or dash, as it is called, is composed of fine gravel, clean washed from all earthy particles and mixed with pure lime and water till the whole is of a semi-fluid consistency. This is mixed in a shallow tub or pail and is thrown upon the plastered wall with a wooden float about five or six inches long and as many wide, made of ½-inch pine and fitted with a wooden handle. While with this tool the plasterer throws on the rough cast with his right hand, he holds in his left a common whitewash brush, which he dips into the rough cast and then brushes over the mortar and rough cast, which gives them, when finished, a regular, uniform color and appearance.

For this sort of work the following proportions will answer: To one barrel of prepared gravel use a quarter of a barrel of putty; mix well before using. This may be colored to suit the taste by using the proper materials, as given further on. It must be understood that the foregoing is the cheapest sort of rough casting, and is not recommended where more durable but more expensive work is required.

The best mode of doing this work as practised in the lake district of Ontario is nearly as follows: Have the frame of building prepared as indicated in the foregoing, with partitions all put in and well braced throughout and well secured. Lath diagonally with No. 1 pine lath, keeping 1½ inches space between the lath. Nail each lath with five nails, and break joints every 18 inches. Over this lath again diagonally in the opposite direction, keeping the same space between the lath and breaking joints, as before. Careful and solid nailing is required for this layer of lathing, as the permanency of the work depends to some extent on this portion of it being honestly done. The mortar used for the first coat should have a goodly supply of cow's hair mixed in with it, and should be made at least four days before using. The operator must see to it that the mortar be well pressed into the key or interstices of the lathing to make it hold well. The face of the work must be well scratched to form a key for the second coat, which must not be put on before the first or scratch coat is dry. The mortar for the second coat is made in the same way as that required for the first coat, and is applied in a similar manner, with the exception that the scratch coat must be well damped before the second coat is put on in order to keep the second coat moist and soft until the dash or rough cast is thrown on. The rough casting is done exactly in the same manner as described for the cheapest sort of rough cast work.

A building finished in this manner, if the work is well done, possesses many advantages over the ordinary wood covered structure. It is much warmer, being almost air tight so far as the walls are concerned. It is safer, as fire will not eat its way through work of that kind for a long time. It is cleaner, as it will not prove such a harbor for insects. It may be made as handsome as desired, for before the rough cast is dashed it may be laid off in panels of any shape by having strips of battens tacked over the soft mortar, which may be removed after the rough casting is done and the coloring finished. It is much superior to the so-called brick veneered house, as it is warmer, more exempt from fire and cheaper.

For 100 yards of rough casting in the manner described the following quantities will be required: 1800 laths, 12 bushels of lime, 1½ barrels best cow hair, 1¾ yards of sand, ¾ yard of prepared gravel and 16 pounds of hot cut lath nails, 1¼ inches long. The gravel should be sifted through a ½-inch mesh screen, and should be washed before mixing with the lime putty.

To color 100 yards in any of the tints named herewith use the following quantities of ingredients: For a blue black mix 5 pounds of lampblack in the dash. For a buff use 5 pounds of green copperas, to which add one pound of fresh cow manure; strain all and mix well with the dash. A fine terra cotta is made by using 15 pounds of metallic oxide mixed with five pounds of green copperas. A dark green color is made by using five pounds of green copperas and four pounds of lampblack. Many tints of these colors may be obtained by varying the quantities given. The colors obtained by these methods are permanent; they do not fade or change with time or atmospheric variations. Many other colors are used, but few stand like the ones named. A brick color may be obtained by the use of Venetian red and umber mixed in whiskey first and then poured into the dash until the proper tint is obtained. In time, however, like all earthy pigments, these colors fade and have a sickly appearance; they answer better in cements than when incorporated with fat limes.—Carpentry and Building.

A NEW RESPIRATION APPARATUS.

DESPITE the improvements made in recent years in apparatus for saving life and making respiration possible in mine explosions and conflagrations in general, the number of lives saved by the use of such apparatus remains lamentably small. In most cases the rescuers succeed in securing only corpses.

This great mortality is due, not to defective or unscientific apparatus, or lack of practice, willingness or courage on the part of the rescuers, but to the fact that the victims cannot be reached in time to save their lives. Even in the most favorable case, when the imprisoned men are reached while yet alive, but unconscious (for more are killed by the suffocating smoke and "afterdamp" than by the direct action of the flames) a comparatively small life-saving crew can accomplish very little in the way of bringing the unfortunate miners to the open air through the long narrow and tortuous passages, which are usually more or less blockaded in consequence of the accident. Nor is much gained by equipping the rescuers with caoutchouc bags of oxygen, for the quantity which can be carried in this manner is too small to be of real service.

It has long been conceded that the only way to prevent this great loss of life would be to provide every miner with an apparatus which would be available at the first moment of the disaster and would enable him to breathe while seeking means of escape, but this principle of self-rescue could not be applied in practice because no apparatus was in existence which satisfied the required conditions. These requirements include moderate cost, lightness, convenience, simplicity and a high degree of efficiency. The respiration apparatus in actual use, on the contrary, containing oxygen compressed into steel reservoirs fitted with reduction valves, is costly, heavy, burdensome and so complicated as to require constant practice in its manipulation.

In recognition of these difficulties Dr. Friedrich Boeck, Prof. M. Bamberger, and Engineer F. Wanz have been for years experimenting with methods of producing oxygen by chemical means as required. The system finally adopted leaves nothing to be desired in point of simplicity, and also satisfies every other requirement of an apparatus for self-rescue. The principle of this "Pneumatogen" apparatus is the reversal of the chemical process of respiration, or the imitation of that process of nature in which the carbonic acid produced by men, animals, combustion and decay is transformed into oxygen through the agency of the chlorophyl of plants. In the Pneumatogen apparatus chlorophyl is replaced by sodium potassium superoxide (Na K O_3), a substance which, on contact with moisture of the breath, evolves oxygen almost explosively, and becomes converted into a mixture of sodium and potassium hydrates (cautic soda and potash). The carbonic acid of the breath is also absorbed by the peroxide, with the formation of sodium and potassium carbonates and evolution of oxygen. Hence if a person breathes through a layer of the coarse grained and porous peroxide contained in a tin box connected at one end with a mouthpiece and at the other with a rubber bag, the exhaled air will be completely regenerated, or converted into air fit for breathing, which will collect in the rubber bag, whence it may be drawn into the lungs with the next inspiration, and this process can go on until all the superoxide has been consumed.

Simple though this process appears it was difficult to devise and construct apparatus for its practical application. These points have been discussed in detail in technical journals.*

Here only a brief description of the two present forms of the apparatus can be given.

The superoxide is contained in a "cartridge" (Fig. 1, *B*) in the upper part of which a filter, *F*, composed of perforated asbestos plates and wire netting, serves to distribute the exhaled air uniformly over the layer of superoxide, and also to remove any alkaline dust from the regenerated air before it is inhaled. In order to protect the superoxide from contact with the moisture of the external atmosphere, which would quickly destroy its usefulness, the necks at both ends of the cartridge are closed by thin sheets of lead, which are to be broken immediately before use. Their rupture is effected by the telescoping of the frame (Fig. 2), each end of which carries a perforating tube K_1 K_2, surrounded by a rubber ring which makes an air-tight joint with the neck of the cartridge. The upper tube, K_1, is connected with a short rubber tube ending in a mouthpiece, *M*, the lower tube communicates with a rubber bag, *H*. The metal parts are covered with a jacket, *I*, and the whole apparatus is kept in a tin case (Fig. 3). When required for use it is taken out of the case and the ends of the frame are pushed together to break the seals and connect the cartridge with the bag and mouthpiece. Then the bag is inflated, the nostrils closed with a clamp and the artificial respiration begins (Fig. 4).

The reaction between the superoxide and the products of respiration is accompanied by a great evolution of heat which raises the temperature of the mixture to from 150 deg. to 250 deg. C. This fact explains the necessity of the non-conducting jacket, *I*. But, notwithstanding this great elevation of temperature the inhaled air always feels cool. This rather surprising phenomenon is due to the dryness of the air and its resultant small specific heat.

With moderate exercise, such as marching with occasional ascent of steps, one cartridge supports respiration for 30 or 40 minutes, but when the body is at rest the time is extended to 100 minutes. This automatic power of adaptation to the demand for oxygen is one of the most important advantages of this system over those now in use, in which the compressed oxygen flows from the steel reservoir at a uniform rate, irrespective of the needs of the organism. In the Pneumatogen apparatus the oxygen is regained from the exhaled carbonic acid and water vapor and produced at a rate proportional to the rate of their production in the body and to the activity of the latter, so that the time during which respiration can be maintained is a function of the work done.

When the cartridge is exhausted it may easily be removed and a fresh one inserted.

The small weight (about three pounds) and low price ($10) of the apparatus, together with its great efficiency and simplicity of manipulation, fully satisfy the conditions specified above. Its usefulness, obviously, is not restricted to coal mining, but extends to every case in which it is necessary to remain for a short period in a space filled with suffocating gases, as in the examination of sewers and wells, in various chemical factories, in burning buildings, etc.

The person using the apparatus breathes easily and experiences no discomfort. During the greater part of the time the proportion of oxygen in the inhaled air is above the normal while the carbonic acid amounts to only a few tenths of one per cent.

As the above-described apparatus does not furnish sufficient oxygen for hard or long-continued labor another form has been devised for the use of the rescue corps. This "working apparatus" (Fig. 5) contains three cartridges, the perforation tubes of which are connected by transverse tubes, above and below, which communicate respectively with the mouthpiece and the rubber bag. The upper transverse tube has a valve operated by a handle, *G*, by which respiration is confined to the middle cartridge, or to the other two, as desired. The outside, or "working" cartridges, are used during the work of rescue and last one hour, while the reserve, or "retreat" cartridge assures to the rescuer, if the exhaustion of the working cartridges leaves him still enveloped in smoke, a half-hour in which to make his escape. The rubber bag is either carried on the back in a basket or is formed like the back of a coat (Fig. 6). In view of the necessity of

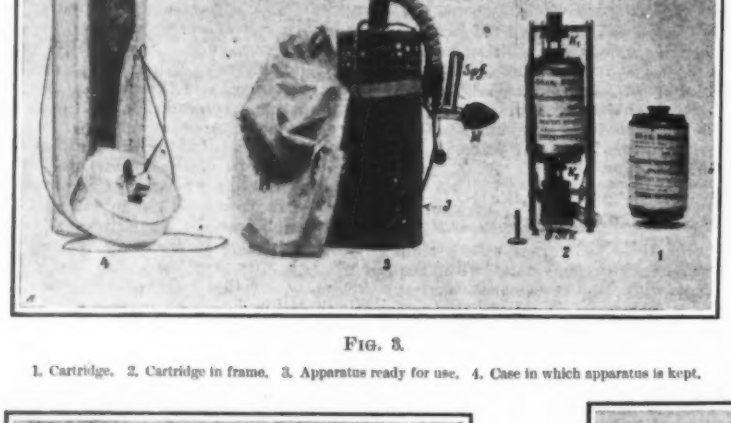


FIG. 3.

1. Cartridge. 2. Cartridge in frame. 3. Apparatus ready for use. 4. Case in which apparatus is kept.

FIG. 2.—CARTRIDGE FRAME.

K_1 K_2, perforating tubes.

FIG. 6.—LARGE APPARATUS IN USE.

A R, air bag.

FIG. 4.—SMALL APPARATUS IN USE.

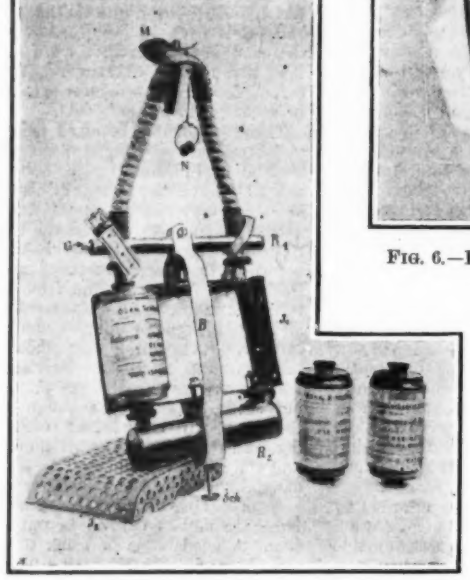


FIG. 5.—LARGE OR "WORKING APPARATUS."

J_1 J_2, jacket.

FIG. 1.—CARTRIDGE.

* Bamberger-Blick "Atmungsapparat zur Selbstrettung, aus dem Bereiche irrespirabler Gase." Zeitschr. f. angewandte Chemie 1904, II. 1429.

Bamberger-Blick "Pneumatogen." Glückauf, Berg- und Hüttenmännische Zeitschrift, Essen 1905, Nr. 25.

Osterr. Zeitschrift f. Berg- und Hüttenwesen LIII (1905), Nr. 25 (Vereinsmitteilungen Nr. 6).

doing hard work immediately after putting on the apparatus it is advisable to charge the bag with about 10 liters of oxygen, because before the superoxide has become well heated, that is to say, during the first six or eight minutes, it does not supply sufficient oxygen for severe labor. This preliminary charge may be obtained very quickly from a reservoir of compressed oxygen or from a rapid superoxide and water apparatus specially constructed for this purpose.

The triple or "working" apparatus provides, as already stated, for one hour's hard work and half an hour occupied in retreating. When no exercise whatever is taken the three cartridges will support respiration for four or five hours. The apparatus weighs about 8 pounds and costs from $30 to $35.

Practical experiments made in several mines and at the mining school in Dortmund have given uniformly very satisfactory results. Although various modifications may be needed to adapt the Pneumatogen apparatus to special purposes (for example, to the use of fire departments) the advantages possessed by this system are already amply demonstrated.—Abstract of Dr. Boeck's article in Die Umschau.

THE SERPOLLET OMNIBUSES AND TRUCKS.

THE success that crowned the Serpollet omnibuses for Paris when they were experimented with first by a committee of the Municipal Council and then by a number of city engineers is well known. Now that delivery trucks are being turned out by the same house, it seems well for us to give some details as to the Serpollet chassis for heavy traction. This is of pressed steel, is mounted on springs and carries all the mechanical parts. The body, which is completely independent, is fixed upon the chassis without connection with any of the parts of the mechanism. The front axle, which is the steering arc, is of mild steel. The reach members are case-hardened and tempered. The hubs run on "patent" journals.

The hind axle is of the fixed type. It is driven through the intermedium of two chains which receive their motions from a shaft at right angles with the chassis, and which carries the differential, with a reduction of 8 to 30. This shaft is actuated by the motor, by means of angle pistons and a shaft with universal joints.

The motive part consists of a generator, a small donkey feed engine, and a motor.

The generator is of the instantaneous vaporization type of 9 elements. Its working pressure is 72 pounds to the square inch. Its heating surface is 60 square feet.

The burner, placed beneath the bundle of tubes, is composed of a tube for vaporizing kerosene or heavy oil, and of which the extremity is connected with a series of steel steps carrying burners (to the number of 30 for heating with kerosene, and 12 for heavy oil) and chambers forming Bunsens. This apparatus is capable of burning 3½ pints of kerosene or heavy oil an hour.

The feed of the generator and burner is effected in a proportional manner by means of a set of pumps controlled by the same lever, so that the volumes produced are always in the ratio of 1 (for the kerosene) to 8.5 (for the water). These pumps are actuated by a steam cylinder. This whole affair constitutes the donkey feed engine, of which the escape steam goes to the smoke stack and creates therein the draft of air necessary for the combustion.

The donkey engine is set in motion and stopped automatically by a regulating apparatus which shuts off the entrance of steam as soon as the pressure reaches 57 pounds to the square inch, and opens it as soon as such pressure lowers.

The production of steam therefore depends on the use made of it, without the driver having to perform any manipulation.

Upon the force pipe of the water pump is placed the safety valve regulated to 64 pounds. This valve can be so manipulated by the driver as to cause the pressure to fall. A gage indicates the pressure of the steam. The motor is a single acting one, with four cylinders of 3-inch diameter and 3.5-inch stroke. It is capable of developing 20 horse-power at a speed of 600 revolutions a minute.

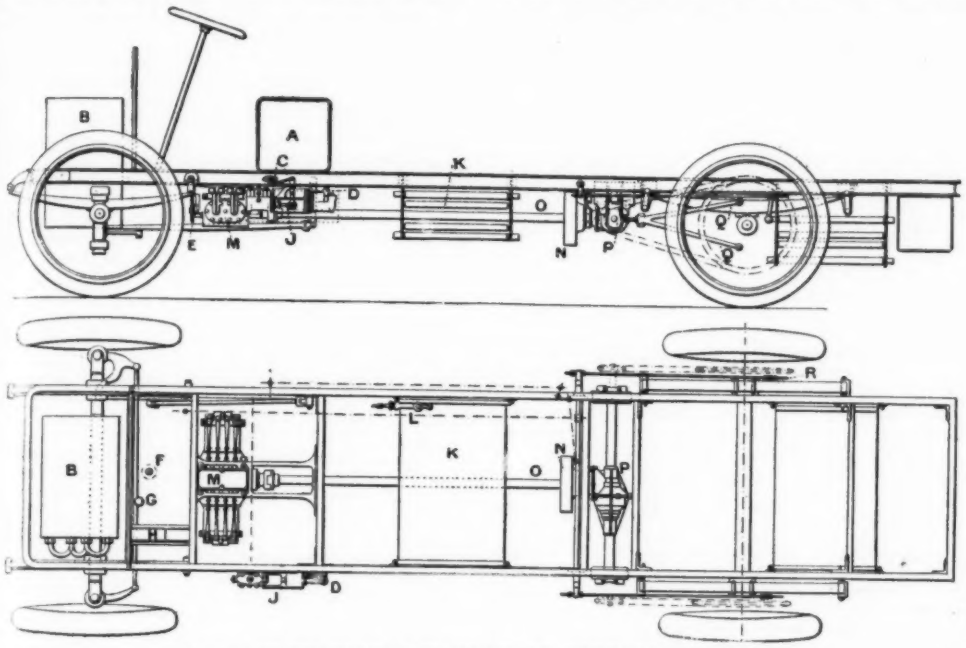


FIG. 2.—ELEVATION AND PLAN OF SERPOLLET TRUCK.

B, Boiler. A, Kerosene reservoir of water tank. G, Filling plug. H, Oil. M, Motor. J, Feed pumps. D, Pump valves. E, Oil pump. P, Shaft of the differential. K, Condenser. O, Condenser shaft. N, Brake. Q, Q, Arms of the chain stretcher.

The speed of the vehicle is regulated by the opening of the distributer, which is maneuvered by a pedal to the left, which is brought back to the closed position by a spring as soon as the driver ceases to act upon it. The distribution is effected by means of valves controlled by cams. These latter are so constructed that the displacement of a lever situated upon the right side of the chassis permits of running the vehicle forward, stopping it, or running it backward. The intermediate positions of the lever in running forward give a variable expansion.

The escapement takes place in a condenser composed of smooth brass tubes, placed at the rear of and under the vehicle, and circulates afterward in a multitubular radiator with cooling flanges, placed in front under the chassis. The water thus condensed is forced to the upper part of the reservoir, without a pump, by the counter pressure of the exhaust. This reservoir is provided with a waste pipe which permits the non-condensed steam, if there is any, to discharge under the vehicle without pressure.

An automatic lubricator with multiple conduits oils all the parts in motion.

The brakes are very powerful and consist of: (1) An internal one with bronze segments that act upon two steel drums mounted upon the hubs of the wheels. Their arc of contact is about 350 deg. This brake is controlled by a pedal and a multiplication of stress of 1 to 12. The braking is effected in both directions. (2) An internal brake of which the pulley is keyed upon the driving shaft at its entrance into the box of the differential. This brake is manipulated by a rack lever with serrate teeth placed to right of the driver. Its diameter is 12 inches, its width 2 inches, and its arc of contact 350 deg. (3) Finally, the driver has at his disposal the most powerful of all brakes, the back-steam.

The broken-axle steering arrangement is controlled by a hand wheel. It acts upon the front wheels through the intermedium of a screw and a system of rods and levers, with a total reduction of about 1 to 9. The weight of the chassis is 3,900 pounds.

The total weight of the truck, unloaded, but with fuel and water and driver, is 4,400 pounds, of which 2,100 are on the front, 2,300 on the rear axle. The maximum speed of a Serpollet truck or omnibus is 15 miles an hour.

A very interesting point is the consumption of the Serpollet "heavy weights." This necessarily varies with the profile of the road traveled. For the Alpine cars of Nice (Nice, Turbie, Menton, and return) it is about 1.4 quart of heavy oil per mile. For the omnibuses in service at Lautarat it is almost a pint. Finally, the 30-passenger omnibus in service upon the Saint-Germain-des-Pres line uses 1.5 quarts of heavy oil per mile.—Translated from La Vie Automobile for the SCIENTIFIC AMERICAN SUPPLEMENT.

SURVEY OF THE SIMPLON TUNNEL.

WE have appreciated many of the difficulties the engineers encountered in the construction of the Simplon tunnel and have offered our congratulations on the successful completion of the work. But the difficulties that have been most readily apprehended have been those arising from the outburst of water from the hot springs in the track, the high temperature, and the mechanical boring and removal of the rock. In the happy completion of a task of great magnitude, which at one time threatened to end in a catastrophe, people are apt to forget the onerous preliminary work necessary to set out the line of the tunnel, to arrange the gradient so as to provide not only for efficient drainage at either end, but to secure the continuity of the separate tunnels at the point of junction, and so render it possible to work simultaneously at both ends. We are therefore glad to see an article by Prof. C. Koppe in Himmel und Erde for August* bringing these matters forward, and making us familiar with the work which has been so efficiently carried out by Prof. Rosenmund of Zurich.

Before the work of boring and perforation can be begun, there are three elements which have to be determined with an accuracy which must be greater in proportion to the difficulties of construction. These are the direction, the length, and the altitude above sea-level. Assuming that the places of entrance and exit of the tunnel have been marked by suitable pillars, the determination of these three elements begins; and that of the level is the least difficult, because the surveying engineer trusts to direct measurements. By the aid of accurate leveling instruments, it is possible to derive the difference in altitude of two stations 50 kilometers apart with no greater error than 3 centimeters. This is effected by the use of the leveling staff, which is read by means of an accurate level, the staff being placed vertically at two stations a convenient distance apart, and the sum of the differences

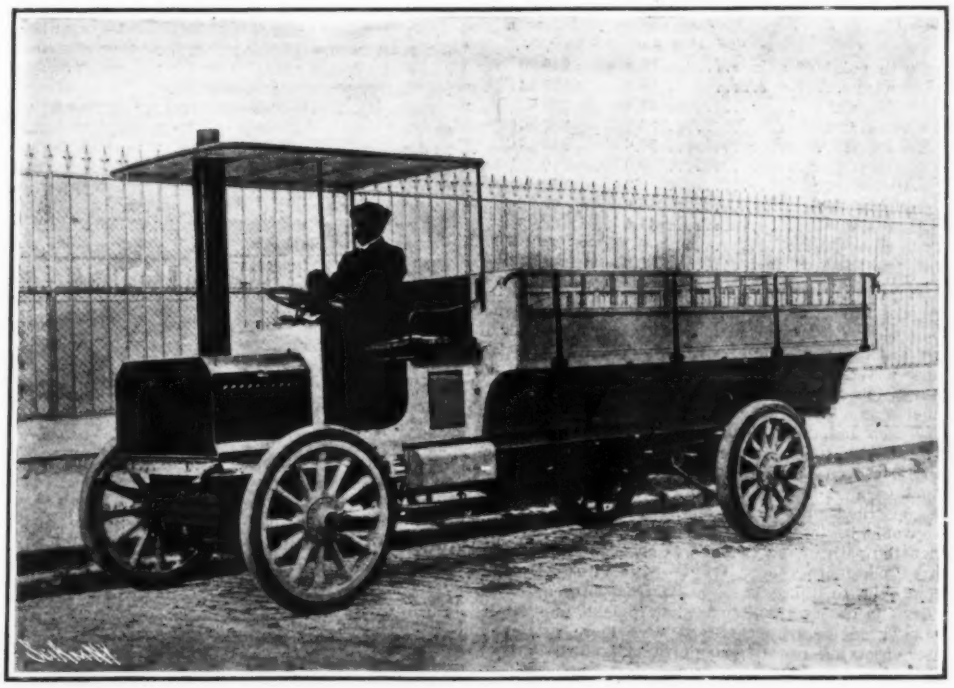


FIG. 1.—A SERPOLLET 20-HORSE-POWER AUTOMOBILE TRUCK.

* Die Vermessungs- und Absteckungs-Arbeiten für den Simplon Tunnel,

of each pair of readings being taken. The surveyor apparently trusts entirely to the accuracy with which his theodolite can be leveled. Several determinations of the difference of level of the two ends of the tunnel were made, but between the two last there was a discrepancy of only 2 centimeters, a more than sufficient degree of accuracy. The actual difference of level between the two ends was 52.439 meters.

The second element, that of the length of the tunnel, is to be derived indirectly from triangulation, the length being reckoned from the same points that have served for the determination of difference of level, and, as a matter of fact, these points are at some distance from the actual openings. A base line being given, the construction and the solution of the triangles present little difficulty, for here great accuracy is not required, and the probable error that Prof. Rosenmund was content to leave in his work amounted to ± 0.7 meter. The distances measured are as follows:

	Meters.
The length between the columns marking the axis of tunnel	20,091.33
Distance of northern column from tunnel opening	317.78
Distance of southern column from tunnel opening	44.84
Actual length of tunnel	19,728.71

The third element, that of direction, at all times presents some difficulty, and, in the case of mountains, where local attraction enters as a disturbing factor, the problem requires very delicate treatment. In a tunnel 20 kilometers long, an error in direction of one minute, which is usually the limit of accuracy sought in technical work, would produce an error of 6 meters, and the tenth part of such an error would be too great. Recourse is necessarily had to triangulation, and the angular measurements must be made with the greatest care. Well-defined signal posts must be erected to mark the angles of the selected triangles, and the points of reference in these pillars defined with the utmost accuracy. The form which Prof. Rosenmund preferred consisted of cylindrical towers of brick about eight feet high, of which the axis was an iron tube the upper edge of which reached the top surface of the tower. A wooden pole carried this iron tube vertically upward, and the whole was surmounted by a conical tin covering, the highest point of which was vertically over the center of the iron axis. Eleven of these piers were erected, and when signals were made from any pillar the conical top was removed, and the theodolite was placed centrally over the middle of the iron tube in the cylindrical tower, which afforded a solid support for the instrument and permitted accurate observation of the other stations. With the care exercised, it might have been anticipated that the sum of the angles of any triangle would differ from 180 deg. by the known amount of the spherical excess, within the errors of observation. But the discrepancies were much larger, varying from 4 to 8.5 seconds, and these deviations could be explained only by attributing to the mountain an attractive force, which sensibly displaced the direction of the plumb-line. In other words, the theodolite was not placed horizontally. The amount of the deviations from the vertical, with the azimuths in which they occur, is shown in the following table:

Station	Deviation from vertical. Sec.	Azimuth Deg. M.
North point of axis	13.9	248 26
Oberried	19.1	195 12
Birgischwald	16.4	188 5
Rosswald	23.6	262 56
Spitzhorn	17.5	314 18
Monte Leone	0.0	0
Hüllehorn	8.2	244 3
Seehorn	5.6	75 28
Alpe Wolf	11.4	36 46
Genuina	9.1	192 3
South point of axis	5.8	139 11

Assuming these deviations from the vertical to arise from the attraction of the mountain mass, an hypothesis which was confirmed by rigorous astronomical observation, it was found possible to reduce the closing errors of the triangles very materially. The solution of the whole network of triangulation showed that the tunnel's axis was fixed with a probable error of ± 0.7 sec., and that the direction of the tunnel could be fixed with sufficient accuracy by pointing the telescope placed on one of the piers at the entrance of the tunnel to any other signal tower and revolving the telescope through a known angle.

It would be interesting to enter into the details by which the path of the tunnel was checked as the work progressed, more especially as curious refractive effects, akin to those seen in "mirage," occurred to render the observations somewhat difficult and uncertain. These disturbing effects were more noticeable when observing toward the north end of the tunnel, where the difference of temperature between the internal and external atmosphere was greatest. On the southern side, the external air being warmer than on the north side, the "mirage" was not so conspicuous. But we have only space to refer to the degree of success which resulted from the care bestowed on this difficult undertaking—a success which could not be adequately tested until the junction of the engineering parties in the middle of the tunnel was effected. To take the three elements in order, it was found that the level agreed within 0.1 meter of the calculations. The length as measured differed 2 meters from the calculated value, but, as mentioned, this was a factor in which great accuracy was not needed, because, if the direction were given correctly, it was only necessary to continue the borings until the engineers from the south and north sides met in the middle. The direction was most satisfactory. The wall of one tunnel was absolutely continuous with the wall of the other; an attempt was made to compare the opposite walls of the tunnel for confirmation, but this attempt was frustrated by a projecting piece of rock. No better result could have been anticipated, and the utmost credit attaches to Prof. Rosenmund and his assistants.

[Continued from SUPPLEMENT No. 1563, page 25047.]

THEORIES OF ORE DEPOSITION HISTORICALLY CONSIDERED.*

By S. F. EMMONS.

The Scientific Period.

THE first scientific period may be said to have been entered on near the close of the eighteenth century, when De Saussure (1779), Pallas (1777), and Werner (1791) almost simultaneously inaugurated by their works the era of positive geology. It was about the same time that chemistry was placed on a scientific basis by the researches of Lavoisier, Scheele, Priestley, Cavendish, and others. Up to this time even the name geology had hardly been recognized, natural history or mineralogy being the titles usually given to works that treated of it, and the few exact facts with regard to it which such men as Agricola, Steno, and others had determined were drowned in a sea of conjectures. On the Continent it was the mining schools that principally fostered mineralogic and geonostic studies, and these had been but recently founded, that at Freiberg, Saxony, in 1765; at Schemnitz, Hungary, in 1770; at St. Petersburg, in 1783; and at Paris, in 1790. Geological literature, especially in Germany, went hand in hand with that on mining and mineralogy.

Of the three men just named, the first two were eminently observers. Pallas, after being called to the mining school at St. Petersburg, had made a six years' geological expedition through the mountains of Russia and Siberia, and De Saussure for over thirty years was largely busied in studying geological phenomena in his native Alps, being the first to climb Mont Blanc and Monte Rosa. He also appears to have been the first working geologist to use the name geology for his science. While neither of these men contributed much to the advancement of geological theory, they added largely to the store of ascertained fact, which is its necessary basis, and their greatest service, perhaps, was in inaugurating geological studies of the great mountain systems of the world, which more than any other branch of geological inquiry have been instrumental in raising this science to its present stand.

The actual field of observation of Werner, on the other hand, was extremely restricted, scarcely extending beyond the confines of his native Saxony. He had, however, a genius for the analysis, classification, and co-ordination of observations, which enabled him to bring order out of the chaos of fact and fancy which then constituted the science. With an eminently didactic mind, he possessed, with much personal charm, such a power of impressing his ideas upon his pupils, that during the forty years that he occupied the chair of mining and mineralogy the Freiberg school was the center of geological studies in Europe. From it emerged so many distinguished geologists, as the fruit of his teachings, that, as Cuvier says, "from one end of the world to the other nature was interrogated in the name of Werner."

Contemporaneously with Werner an equally great service was being rendered to geology at Edinburgh, in Scotland, by James Hutton, who, like so many of the eminent geologists of the world, had been educated as a physician. Hutton, like Werner, taught mainly through his lectures, neither of them finding time for much writing, so that the doctrines of either have become known to posterity mainly through the publications of their pupils.

Each of these great teachers aimed to discard theory and to build their respective systems on a basis of ascertained facts, but in the then existing condition of geological investigation certain fundamental conceptions had to be assumed from the interpretation given to as yet imperfectly studied phenomena. With minds like theirs, strong in the courage of their convictions, an interpretation once fairly reasoned out and accepted became an established fact, and thus it came about that through a difference in their premises their respective systems were diametrically opposed and gave rise to the great controversy between Neptunists and Plutonists, which for nearly fifty years divided the scientific world of Europe into two antagonistic schools. Werner assumed that the earth had once been surrounded by an ocean of water at least as deep as the mountains are high, and that from this ocean there were deposited by chemical precipitation the solid rocks which now form the dry land. He entirely ignored the internal heat of the globe in its influence on crystalline rocks, on ore deposits, and as a cause of the dislocations of stratified rocks. Hutton, on the other hand, while not ignoring the agency of water in the formation of the sedimentary rocks, ascribed to subterranean heat and the expanding power it exercised their final consolidation, their disturbed condition, and the changes produced in the older rocks, to which Lyell later gave the name of metamorphism.

Neither made any distinction between dikes and mineral veins, but while Hutton supposed fissures and openings to have been formed from time to time which reached through the external crust down to the hot nucleus, and that both were formed by molten matter forced up through them toward the surface, Werner, on the other hand, taught that they were contraction fissures which were filled by material held in suspension or in solution; that a primeval ocean once covered them, and hence they must have been filled from above.

In general matters Hutton's reasoning and observations were both broader and more logical than Werner's, and his views have hence proved more enduring, but he had little, if any, personal knowledge of ore deposits. Werner made their study an important feature of the geologist's training, and his principal publication was entitled "A New Theory of Vein Formation." Although this work was the only important one exclusively devoted to the subject, owing to the fatal defects in his geological premises, it contributed little to the permanent advancement of that branch of the science, and it may even be questioned whether it did not retard it, since through the great weight of the author's name it remained a standard work in Germany long after many of his peculiar geological theories had been discarded. Its merit lay less in the novelty of the views advanced, most of which had already been put forth by one or another of his predecessors, than in the logical way in which they were presented.

The principal points with regard to the origin of ore deposits which may be considered as fairly well established by Werner's teachings are that they are the filling of fissures and cracks of later formation than the inclosing rocks, and consist of foreign material subsequently introduced, largely in aqueous solution. As to the fissures themselves, while a certain systematic arrangement had been noted in their directions, and the fact that, where by intersection, one had been shifted or faulted by another, inferences as to their relative age might be drawn, little definite conception was apparently had as to their origin beyond the general suggestion that they might be the result of subsidence or of contraction of the rock masses in which they occur.

Any important advance over these rather crude conceptions was hardly to be looked for until very decided progress had been made in the broad general theories of geology, and this progress was necessarily very slow. Although the period of reasoning from facts of nature to generalizations had commenced, the tendency to pure speculation was not yet extinct, and resulted in many remarkable theories, such as that put forth by Professor Oken, of Jena, who, in his textbook of "Natural Philosophy" (1809), assumed that the earth was a polyeder formed according to the laws of crystallography, and that veins or fissures resulted from the loss of the water of crystallization. For the genesis of ores, darkness, earthy water, and air are necessary; hence there can be no ore in the interior of the earth, since no air reaches it, etc. Or, again, that of Breislak, the Italian geologist (1811), who put forth a Plutonic earth theory which supposed that while the rocks were still in a molten condition the metals had a tendency to separate under the influence of specific gravity and of certain chemical and physical affinities, and localized themselves in veins without entirely separating from their country rock. This is apparently the first enunciation of the modern theory of magmatic segregation. The metallic grains in placers he supposed to have been granulated like slag on coming in contact with water.

The peculiar views of Werner naturally held sway longer in Germany than elsewhere, yet it was his favorite pupils that were first led, in their widening fields of observation, to abandon his theory that basalt is of aqueous origin, though altered by the heat produced through the combustion of neighboring beds of coal.

Von Buch, for a long time the leading geologist of Germany, was perhaps the first to whom doubts came as to the correctness of his master's teachings, while studying an eruption of Vesuvius in 1799, though he refrained from immediate publication of these doubts.

D'Aubuisson, the French geologist, after visiting, in 1804, the volcanic regions of Auvergue, also became convinced of its igneous origin and published a recantation of the views maintained in his essay of the previous year on the aqueous origin of the basalts of Saxony. Finally, von Humboldt (1810), perhaps the greatest of his pupils, in his extended observations in the Cordilleran system of the American continents, traced a direct connection between metallic deposits and the eruptive rocks.

Observation must have convinced many of Werner's pupils of the untenability of his peculiar views on the formation and filling of veins long before their final refutation was published by his successor, Von Beust, in 1840, but reverence for his memory doubtless prevented a definite expression of their opinions in print.

Von Herder, in his work on the Meissner adit, published in 1838, classified the various theories on the origin of veins that had been held up to that time, as follows:

1. Theory of contemporaneous formation (with the inclosing rock).

2. Theory of (filling by) lateral secretion, or by material derived from the inclosing rocks.

3. Theory of (filling by) descension, or filling from above.

4. Theory of (filling by) ascension, or filling from below, the latter subdivided into;

* Annual address by the president of the Geological Society of America, read before the society at St. Louis, Mo.

(*a*) By infiltration, or solutions from mineral (thermal) waters.
(*b*) By sublimation, or by ascending steam.
(*c*) By sublimation, or in gaseous condition.
(*d*) By injection or in igneous fluid state.

He was thus apparently the first to apply the now time-honored terms "ascension," "descension," and "lateral secretion," though the idea was clearly expressed thirty years before by Cuvier's collaborator, Alexandre Brogniart, when, in an attempt to reconcile the Huttonian and Wernerian schools, he showed that no one theory could fit all kinds of veins.

The theories of contemporaneous formation and of descension had by this time become practically obsolete among the Germans, and had never had much standing among geologists of other nations. German geologists, who had been the most assiduous students of vein phenomena in the field, have always been inclined to assume that vein minerals have been deposited by precipitation from aqueous solution, differences of opinion having been mainly as to the provenance of the waters. Doubtless the influence of Werner had much to do with their mental attitude, but it is also to be remarked that this method of formation best fits the ore deposits of their country.

In England, the home of Plutonism, on the other hand, no very decided views on theories of ore deposition were held. John Maccullough, in 1821-1823, after a discussion of the Wernerian-Huttonian views, wisely concludes that it is necessary to study nature's processes more closely before a satisfactory theory can be formulated. He enumerates the minerals occurring in ore deposits which may be formed by infiltration or solution and by sublimation, contending that many vein minerals can be produced in either way, and recommends further investigations along that line.

John Taylor, in his report on mineral veins to the British Association in 1833, makes a similar review and arrives at similarly indefinite conclusions.

Later, De la Beche, in his Geology of Cornwall (1839), says:

"The theories of the day divide themselves into, first, the contemporaneous formation of mineral veins with the rocks which inclose them; second, the filling of fissures formed in rocks by the sublimation of substances driven by heat from beneath upward; and, third, the filling of fissures in rocks by chemical deposits from substances in solution in the fissures, such deposits being greatly due to electro-chemical agency."

The contemporaneous theory, according to him, was still generally held among Cornish miners, but he himself is evidently more inclined to the theory of deposition by solutions ascending under the influence of internal heat, the water being furnished from the sea, which covered many of the Cornish lodes.

The electro-chemical theory, which had already been suggested in 1810 by Bergrath Schmidt, and for a time enjoyed a certain popularity among English geologists, was founded mainly on observations made on the mine waters of Cornwall by Robert Ware Fox. This theory assumed that vein minerals had been precipitated from solution under the influence of electrical currents. It would appear, however, that, owing to the imperfect knowledge of chemistry of that time, the believers in this theory assumed electric currents to be a necessity for the production of certain reactions when they only serve to facilitate them. Fox's observations on the action of mine waters on minerals were, moreover, rendered somewhat inconclusive by the fact that he did not distinguish between primary vein minerals and those that have been formed during their secondary alteration by surface waters.

Among French geologists Plutonist views were predominant from the first; even those who, under the influence of Werner's magnetic teachings, had for a time embraced his Neptunist theory soon recanted it when their field of observation had widened to include volcanic regions. The cosmic theory, generally known as the "nebular hypothesis," the one which has been most universally accepted by geologists as an explanation of the earth's beginnings, as finally received, was the work of a French mathematician, Laplace (1796). Hence, in seeking to account for the origin of ore deposits they were naturally inclined to look for igneous agencies. Thus, A. Burat, well known through his work, "Applied Geology," 1843, took extreme Plutonic views and divided the copper, lead, and iron deposits of the Italian peninsula, which he had especially studied, into (1) dikes or eruptive masses, with gangue of amphibolite and livaite; and (2) irregular veins of contact between eruptive serpentine and sedimentary rocks. The Elba deposits of specular iron, which he regarded as striking instances of the first class, he considered to have exercised an elevatory as well as metamorphic action on the inclosing rocks at the time of their injection. Fournet, another prominent authority on the subject, maintained a theory of igneous injection for vein fillings as late as 1859.

As in Germany, it was the professors in the mining schools, especially those at Freiberg, who, in the early part of the century, led in forming scientific opinion as to ore deposition, so it was the School of Mines at Paris which later furnished the leaders in that branch of geological thought.

The French students of underground phenomena were at a certain disadvantage as compared with their German brethren, in that they were obliged to travel to foreign countries to study large mines, whereas the German schools were all situated in the midst of important mining districts. On the other hand, while the German displays great industry and acuteness of observation in his collection of facts, the Frenchman has a remarkable faculty of logically grouping them and of clearly and concisely stating the conclusions to be drawn therefrom. The French language, moreover, by its structure is much better adapted to a concise presentation of scientific concepts that may be readily understood by the reader than the German, which is likely to be involved and cumbersome in its mode of expression. Hence, toward the middle of the century the influence of the French geologists on genetic speculation became predominant, especially as it was based on synthetic experiment, a branch of geological investigation which for a time they practically monopolized.

The first of the French geologists who has left an enduring impression upon the theory of ore deposits was Elie de Beaumont, who for nearly fifty years occupied the chair of geology at the Paris School of Mines (1827-1874). In 1847 he published, as an abstract of his lectures, his well-known paper "Volcanic and metalliferous emanations," in which he does not claim to formulate a complete or final theory, but presents his views as explanations which seemed to him best to fit the facts of nature as then known. His conclusions are, briefly: That the metallic minerals in veins of incrustation (since called crustification) find their ultimate source in eruptive rocks, from which they emanate at first in gaseous form. As they pass through long canals or fissures, at greater distances from the center of eruption, they must condense and thus form deposits analogous to those of springs at their point of exit. The metals in veins are found united less frequently with oxygen than with certain elements to which the name "mineralizers" has been given, and which are not only volatile themselves, but possess the property of rendering volatile many substances with which they combine. These are sulphur, selenium, arsenic, antimony, phosphorus, tellurium, chlorine, bromine, iodine, etc.

Mineral springs he divides into principal or hottest thermals, which are fed by gases emanating directly from eruptive masses which reach the surface in a fluid state, and, second, less heated springs, which often accompany the former. The latter are fed by meteoric waters, which descend until they come in contact with hot rocks and, when heated, ascend again, in which journey they may be charged with mineral substances.

Vein deposits may be formed by either class of thermals; the second class would form deposits not only in ordinary fissures, but also in those already charged by direct emanations. It is difficult to account for the gangue minerals as direct emanations, since they are not volatile except such as are combined with fluorine. Certain deposits without gangue in eruptive rocks and deposits in limestone in contact with eruptive rocks, associated with garnet, livaite, and similar minerals, may have been deposited by sublimation, but these are exceptional. For most veins he admits, in accord with Bischof, that the earthy minerals must have come from the decomposition of the country rocks. The greater proportion of true veins (veins of incrustation) he considers to have been formed by deposition from waters circulating in cracks in the earth's crust. In this, his theory resembles Werner's, but differs from it in assuming that the solutions were ascending rather than descending. Werner's argument in favor of descending waters, namely, that veins become poorer in depth, he considers not well founded, the facts of nature rather going to prove that the solutions became weaker as they approached the surface.

Stanniferous veins, which contain a great number of the rarer elements and are associated with acid rocks, are the type of the first class, while ordinary or plumbiferous veins, which are characterized by the important rôle of mineralizers and the absence of anhydrous silicates, are usually associated with basic rocks.

His reasoning is evidently based largely on his observations in Cornwall, and on an assumed difference in the origin of granite and of volcanic rocks in general. Granite, he assumes, owes its crystallinity less to the fact of having crystallized at great depths than to its content of water (2 to 3 per cent), which enabled it to remain in a pasty condition much below its fusion point, and thus allowed quartz to take the impress of other minerals. The minerals of the first group of veins form part of the outer crust (penumbra) of granite bodies, as granite once formed the outer crust of the earth.

The products of volcanic eruptions he divides into two classes: (1) the lava-like, which consist of silicates in a molten condition; (2) the sulphur-like, which emanate in a molecular condition. To the latter alone can the formation of vein minerals be attributed. The term "solfataric," which was employed by subsequent writers to describe the action of the sulphur-like emanations, has since been very generally used by writers on ore deposits in a sense which is not always strictly accurate.

Although De Beaumont's views are based on some premises no longer considered tenable, they mark an important advance in this line of research, in that they may be said to be the first fruits of organized field investigation, for the first geological surveys, those of Great Britain and of France, had been founded about ten years before, and the first geological map of France had recently (1841) been completed by the latter survey, of which he was the founder and director.

This was also an era of experimental investigation, as well as of observation in the field. Following the example of Sir James Hall, who had, as early as 1805, spent some years in experimenting on the transformation of rocks under the combined influence of heat and pressure, French geologists were actively employed in attempting, by synthetical experiment in the laboratory, to imitate the processes of nature in the formation of rocks and minerals, especially of vein minerals. Prominent among those engaged in this work were Berthier, Becquerel, Ebelmen, Durocher, Sénarmont, and Daubrée. At first with heat alone and later employing heat and water combined, always under pressure, they succeeded in reproducing artificially a great number of the minerals of rocks and veins. Sénarmont (1849-1851), by the aid of water at temperatures of 130 deg. to 300 deg. C., formed artificially thirty of the principal minerals found in ore deposits, including quartz. The results of these experiments did not, however, prove decisively the agents which nature has employed, since they demonstrated that the same mineral may be formed by several different methods. This was appreciated by Daubrée, who, commencing his synthetical experiments with the artificial production of cassiterite in 1844, carried on experimental investigations into the mechanics of rock fracturing, the flow of subterranean waters, and rock metamorphism in general to near the close of the century. He was particularly impressed by his studies of the mineral processes that have gone on since Roman times in the masonry of old thermal establishments at Plombières, Bourbonne-les-Bains, and elsewhere, in which he thought to trace the actual processes of vein formation. His works, "Experimental Geology," 1879, and "Subterranean Waters," 1887, which contain the first philosophic discussion based on experiment of the physics of the rock fractures that constitute canals for the circulation of underground waters, are still classic works of reference for the students of ore deposits. Daubrée understood veins to be fractures formed by dislocations of the earth's crust under pressure strains and filled by deposits from aqueous solutions, generally heated by contact with igneous rocks, from which in certain cases they may have directly emanated. From his observations at Plombières he inferred that most minerals are soluble if given sufficient water and time, and that great heat and pressure are not absolutely necessary prerequisites. Some of the materials of veins, he admitted, may have been derived from the surrounding rocks.

The middle of the nineteenth century was characterized by the increasing use of laboratory experiments in chemistry and physics as aids in testing the current theories of vein formation, as is shown in the preceding sketch of progress of opinions among French geologists.

Similar progress was going on in other countries, especially in Germany, which was more particularly a country of mines and mining engineers, though among students of this subject there was less solidarity of opinion than with the French, and their investigations for a long time were rather on chemical than on physical lines.

A great impulse to increased accuracy in geological investigation was given by the classic work of G. Bischof, "Physical and Chemical Geology," 1846-47, which discusses in a masterly way the processes involved in most of the known geological phenomena, largely on the basis of the author's own researches and experiments, and which may be said to have raised chemical geology to the rank of a distinct science. In the course of his investigations, Bischof, having found that the constituents of the gangue minerals of veins are found in the country rocks, thought it probable that the metals of the sulphide ores might also exist in these rocks in the form of silicates. Later, and independently, Forchhammer, the Danish chemist, in the course of his long continued investigations of the waters of the ocean, detected minute amounts of many of the metals of ore deposits both in sea water and in different varieties of rocks. It was long before the suggestions offered by these discoveries had any practical effect on ore-deposit investigations.

The leading authorities (on ore deposits) of that period were Von Beust, Breithaupt, H. Müller, and Von Cotta. The latter for over thirty years occupied the chair of geology at Freiberg, during which time he had opportunities of visiting most of the important mines of Europe. His text-book on ore deposits (1853-1859), which up to the end of the third quarter of the century was the standard authority both in Europe and America (through Prime's translation, 1869), may be assumed to be a good exponent of the knowledge of the time. It gives a fair-minded statement of all the theories which had been given to account for the formation of vein minerals, showing, however, a leaning toward the infiltration or hydrothermal theory of vein filling, based on the fact that some of the most common constituents are found in existing thermal waters, and that thermal waters containing CO_2 or H_2S are found in the deeper workings of some mines. In general, however, his views, whether on classes of deposits or individual types, do not betray the firm conviction that would result from an exhaustive and systematic study. Moreover, the fact that his classification of deposits is based on the more or less accidental character of form, without any reference to genesis, would indicate that his genetic ideas were still in a tentative state.

In 1873 Prof. F. Sandberger, feeling that the current theories inadequately explained many of the phenomena of vein deposits, followed out the suggestions of Bischof by making an extended series of analyses of the country rocks of veins. Separating previous to analysis the constituent minerals of the rocks by means of solutions of varying densities, he succeeded in demonstrating to his own satisfaction that the characteristic minerals of different deposits are contained in the basic silicates of the adjoining rocks, and in 1880 propounded his theory of lateral secretion, according to which the mineral contents of veins are derived, not from some unknown depth, but from the immediate

wall rock, being brought in by percolating waters which are not necessarily at a very high temperature. As against the thermal-spring theory, he argued that a very small proportion of known thermals contain any of the metallic minerals whatever, and none in the state of sulphides; further, that the deposits observed in their channels have been precipitated in immediate proximity to the surface and under physical and chemical conditions that differ essentially from those that must have prevailed at the depths at which veins were formed.

Sandberger's theory, though for a time it found many adherents, was bitterly contested, especially by Stelzner, Von Cotta's successor at Freiberg, and by Posepny, professor at the Mining School of Pribram, in Bohemia. They maintained that the facts in their respective districts disproved the lateral secretion theory in the restricted sense in which Sandberger employed it, and they demonstrated by a repetition of his analyses that, owing to imperfect methods, he had not proved the metals he found to be necessarily original constituents of the rocks in which they were supposed to occur. Whatever opinion may be held as to the merits of Sandberger's theory, as such, it undoubtedly contributed to the advance of the study of ore deposits in stimulating what may be called "verification;" that is, the practical testing of theory in its application to concrete instances in nature.

In general it may be said of the period that was now closing that, though facts of observation and experiment had been accumulating, the advances in the study of ore deposits during that time were much less than those that had been made in other branches of geological science.

(To be continued.)

THE EDISON IRON-NICKEL ACCUMULATOR.*

By M. U. SCHOOP.

INTRODUCTION.

SINCE the year 1900, a number of published statements have appeared worthy of more or less serious attention, discussing the Edison accumulator, with electrodes of iron and nickel in caustic potash. The name of Edison as well as the long-felt want of an efficient transportable accumulator, not an improved

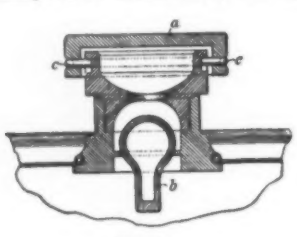


FIG. 1.

form of the lead storage battery, were sufficient to arouse general interest in these communications, notwithstanding that they were mainly laboratory reports and experiences.

As far as the literature on the subject and the numerous Edison patents have shown, the iron-nickel accumulator was preceded by a series of other attempted combinations, of which the cuprous oxide-zinc accumulator may well be considered the first. Properly recognizing the principle that soluble electrodes are impracticable for an efficient accumulator, Edison then removed the zinc from the combination and replaced it by cadmium, which at the discharge of the battery changes into an insoluble oxide. It is quite true that the cheap zinc has a very small electro-chemical equivalent, and one kilogramme gives, theoretically, when used as the active mass in an accumulator, 819.8 ampere-hours; but the disadvantages of an extraordinarily high solution-tension and the difficulty in evenly reforming during the charging, make the advantage of the zinc illusory. The faults of the cuprous oxide-cadmium accumulator consisted in that the available tension was only 0.4 volt and that cadmium was expensive, and could be obtained only in small quantities. When charging, the formation of cuprous oxide, which differs from the protoxide in being slightly soluble in KOH, cannot always be avoided, so that the cuprous oxide also does not completely fulfill the requirements for a perfect electrode. In place of the cuprous oxide, mercury or nickel oxide was now tried, and finally Edison discarded cadmium and replaced it by iron. Plates prepared with mercury oxide give a considerable storage capacity. On the other hand, the use of quicksilver is combated by its high cost and poisonous qualities, and moreover the danger that in the reducing the mercury will run together in pellets is ever present. For the counter electrode, Edison for a time tried to employ zinc-covered magnesium plates, with a zinc solution as electrolyte.

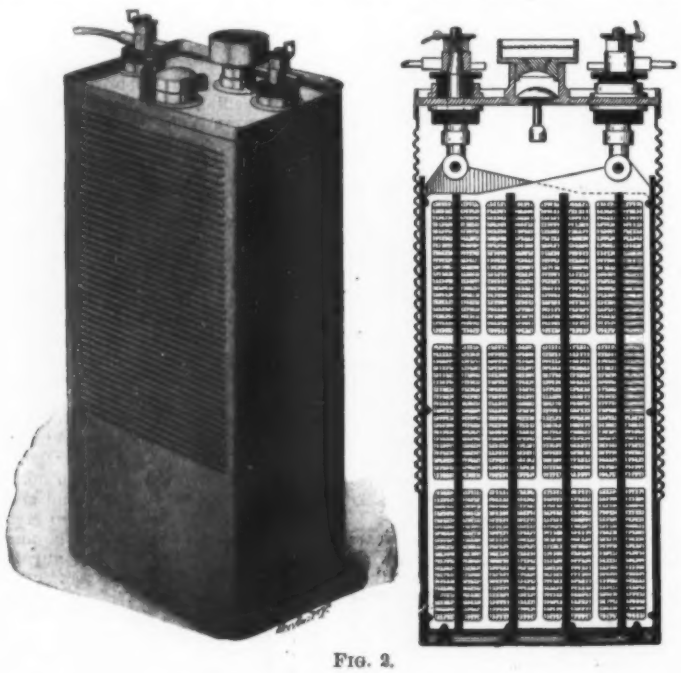


FIG. 2.

Thus iron-nickel provides the combination for the present-day Edison accumulator, and through this is realized the true principle of the accumulator, in which two different metals are used, which are insoluble in the electrolyte during every phase of the charging and discharging, and in which the current-forming action can truly be considered as an oxygen transposition from one electrode to the other. Dr. A. E. Kennely has therefore characterized this class of accumulator as oxygen lift cells.

The following data and test results refer to an Edison cell which came into my hands in February, 1905, and which differs from the previous type D, concerning which a number of communications have been made public, in various improvements, especially of a constructive character. The complete results of my experiments are given below.

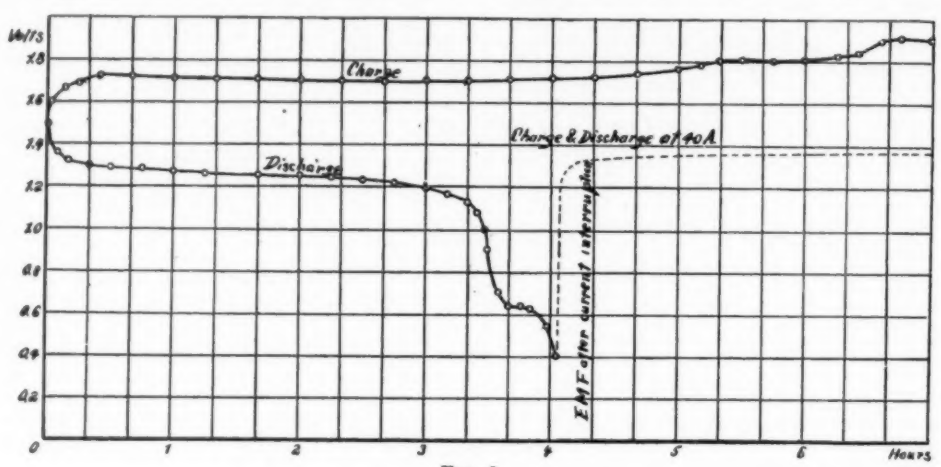


FIG. 3.

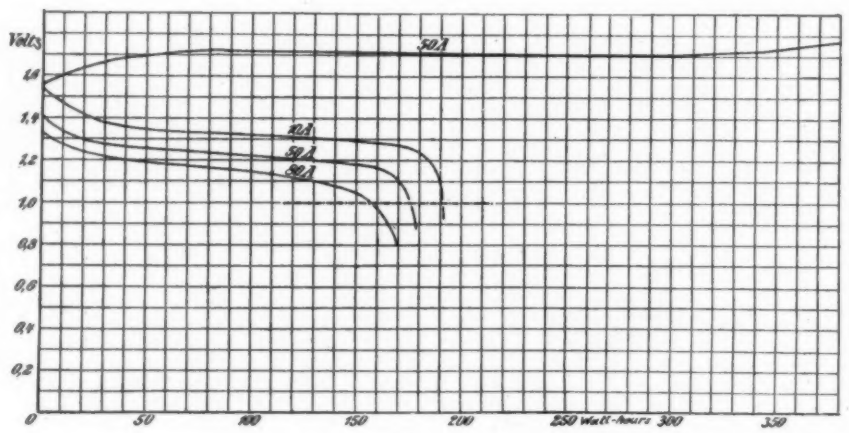


FIG. 4.

Characteristic data for this accumulator are as follows: Height 310, width 65, length 127 millimeters; weight, without electrolyte 4.5 kilogrammes, with electrolyte of a specific weight of 1.2, 5.45 kilogrammes; six nickel and twelve iron electrodes, dimensions 235 x 120 millimeters; weight of one nickel electrode, 160 grammes; weight of one iron electrode, 164 grammes.

To the height, 310 millimeters, of the vessel must be added the height of the binding posts, so that the operative cell would have a vertical dimension of at least 340 millimeters.

THE JAR.

The jar or vessel, made of 0.4 millimeter sheet steel, is nickel-plated inside and out, and in order to increase the mechanical resistance is provided with horizontal corrugations, which do not quite reach the edges. The bending and subsequent shaping by hydraulic pressure, formerly used by Edison, as well as the joining of the edges with cadmium solder, are advantageously avoided in this type by means of electric welding. The weld joints on the long side and on the lid are easily recognized. With the exception of the lid, the entire vessel is provided with a coating of black varnish which, however, was partially destroyed during the tests, by coming in contact with hot water and lye.

The coating of varnish serves less as an electric insulator than to hinder the outward radiation of heat, for as will be shown below, the Edison accumulator, in common with the lead accumulator, possesses the property of having a higher capacity with the heating of its electrolyte.

As a strong development of gas is unavoidable during a large part of the period of charging of the Edison accumulator, precautions must be taken to prevent the splashing out of the lye, and for this purpose Edison proposed and tested a number of valves. The present valve (Fig. 1) consists substantially of a round casing with a lid *a;* in the lower half of the casing a pear-shaped hollow glass body *b* is placed, which begins to play even with a very slight increase in the pressure of the gas, and when it rises for an instant, permits the entrance of the excess of gas into the upper part of the casing. The same working principle is found in the casing-lid, with the difference that because of a greater weight, the gas-pressure under the same must be considerably higher before the lid is lifted. This is prevented from falling off by two projections, *c*, which engage with an annular groove in the wall of the valve. As a floating body was not provided in the former valve, it sometimes happened

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the Elektrotechnische Zeitschrift.

that by a violent development of gas a quantity of the solution entered the valve-casing and was forced out of the same. To permit the entrance of the KOH, the top of the jar is provided with a short vertical tube fitted with a hinged lid and made tight by means of india-rubber. The lid is secured to the tube by means of a finger, and it springs open of its own accord as soon as the finger is moved laterally. The two binding-posts, narrowing at their upper extremities, are insulated from the metal top by means of hard-rubber sockets, and are set into the same in such a manner that the creeping of the electrolyte is entirely obviated. On the upper part of the side walls of the vessel, as well as on the bottom of it, round protuberances are pressed into the metal, and these serve to retain the cell in its proper place in the battery trough, and register with correspondingly formed insulation pegs.

There can be no doubt that with respect to weight, certainty of operation, and length of life, the sheet-steel casing is superior to the best hard-rubber vessel, and if manufactured in larger quantities, is cheaper to produce.

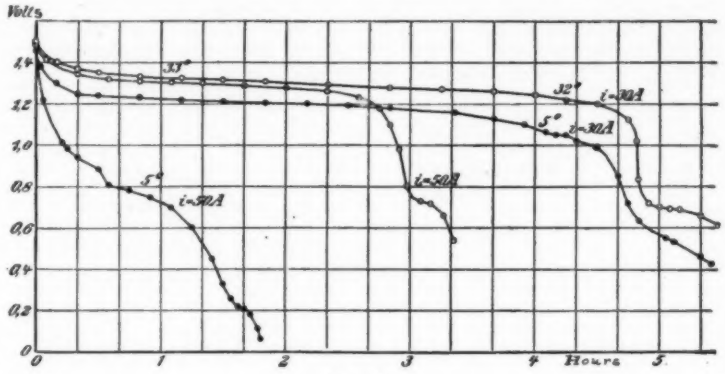


FIG. 5.

ELECTRODES.

There is practically no difference between the electrodes of nickel and those of iron. After a certain period of use, however, brown streaks appear upon the iron electrodes, while the nickel retains its original bright appearance. Small pocket-like holders made of thin, carefully nickeled sheet steel and placed 24 in a grid (Fig. 2) serve to contain the active masses. The grid, which is also nickeled, is stamped out of 0.6 millimeter sheet steel. The upper rim of the plate is tapered to insure a homogeneous division of the current, and is provided at the wider end with an eye to receive the current-carrying bolt pin. To make the pockets, a thin strip of spring steel is drawn between two perforating rollers, cut into plates of the proper size and then formed into small cups which, with the exception of their side walls, are provided with perforations of an extraordinary degree of smallness.

The active mass is introduced into the pockets in the form of briquette. Then one pocket-half is placed upon the other, and the window-like grid, provided with the filled pockets, is placed under strong hydraulic pressure. In this manner the upper surfaces of the pockets are pressed downward, and at the same time the edges are bent over the rims of the grid. After the pressing under flat surfaces, the grid is placed beneath fluted dies, whereby the walls of the pockets are laterally corrugated. Aside from the additional stiffness produced by this, a consideration which is of considerable value because of the decided change of volume, especially of the nickel mass, an increase of surface is achieved by this means, as well as an increase of the contact of the particles of the mass with the supporting metal.

According to the German patent No. 157,290, of February 6, 1901, Edison's invention consists in an accumulator with an unchangeable alkaline electrolyte, whose positive electrode contains oxygen combinations of nickel, and whose negative electrode contains oxygen combinations of iron, or metallic iron, or a mixture of both, as active masses. It has not yet been determined what are the constitutional formulæ of these substances, both in a charged and discharged condition, and what reactions, moreover, take place during the charging and discharging. E. F. Roeber conjectures that the positive electrode contains NiO_2 when loaded, a hitherto unknown combination, as the highest present degree of oxidation of nickel is represented by Ni_2O_3. More probably, however, the formula for the charged positive mass is that corresponding to black nickel hydroxide, $Ni_2O_3.3H_2O$. It may be stated for this view that according to Streintz the anhydrous nickel oxide is a non-conductor, while the conductivity of the Edison nickel mass is an exceptionally good one, as we will see below in the discussion of the internal resistance. The nickel hydroxide can be produced chemically or electrically. Edison, however, as far as can be gathered from the patents, gives the preference to the chemical method. A boiling solution of nickel nitrate is precipitated with magnesium hydroxide. The apple-green precipitate is nickel hydroxide, and this is washed in a large quantity of water, in order to be used immediately or not till the complete oxidation by means of dry chlorine. (British patent No. 2,490, February 5, 1901.) The hydroxide, which has been received and dried at ordinary temperature, is further oxidized electrically in the forming. Recently Edison has been enabled to increase the capacity of the nickel mass some 20 per cent by the addition of bismuth oxide. This is of importance, as in equal volume and weight finely divided iron reduced by hydrogen possesses a capacity almost twice as great as that of the nickel hydroxide.

For the production of iron highly active electrolytically, Edison employed various methods, and in these attempted to utilize iron monosulphide, iron protoxide, and forge scales. In principle the problem consists in producing an iron-oxygen combination containing as small a quantity of oxygen as possible, in other words a combination most closely approaching iron protoxide (FeO) which is capable of burning in the air. A method by means of which reliable results are easily achieved and by which, in all probability, the negative masses of the latest Edison accumulator, manufactured in large quantities, were produced, consists in passing hydrogen for a number of hours over clean, dried iron oxide in a closed chamber, at a temperature of 260 deg. C. The chamber is then allowed to cool off to ordinary temperature, the hydrogen process continuing, while the re-oxidation of the mixture of iron protoxide and magnetic oxide thus obtained is prevented by spraying water into the cooled retort. In a later German patent of 1903, Edison recommends a temperature of 480 deg.

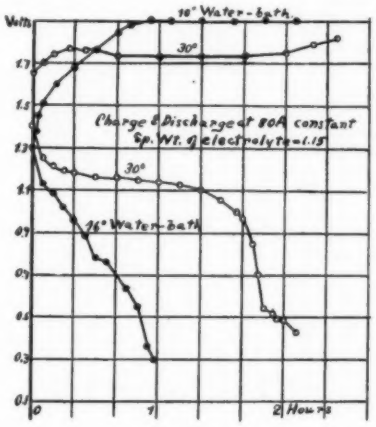


FIG. 6.

In the earlier type the nickel as well as the iron masses were mixed with flake graphite in order, on the one hand, to increase the conductivity, and on the other hand, to prevent the washing out of the masses through the perforations during the act of charging. However, the value of the graphite addition lay primarily therein that in spite of heavy pressure of the mass-brickets, it preserved a certain porosity, which in the interests of good diffusion, and because of the unavoidable change of volume of the active masses, is unquestionably necessary. Lately the practice of adding graphite to the iron mass has been discontinued entirely, and copper and mercury substituted therefor. There is the danger, it is true, that should an accidental change of poles take place, these substances, insoluble as metals in the electrolyte, would become oxidized and subsequently dissolved. A knowledge of this doubtless very recently induced Edison to leave out the copper entirely and to use mercury alone to increase the conductivity in the amalgamation of the iron. In examining an iron electrode with a strong microscope, a considerable number of shining globules can be remarked, which are nothing more or less than the quicksilver reduced by means of electrolysis. The tendency, however, of the mercury to form into globules when in the metal shape causes a question to arise as to its value as a contact improver.

The weight of a complete iron briquette is 7.053 grammes, that of the iron mass alone 5.136 grammes, that of the retaining pockets therefor 1.917 grammes. The specific weight of an iron briquette was found to be 4.874, that of the mass itself 4.304.

The mass contains some 20 per cent of mercury, and when quantitatively analyzed gave a total iron content of 73.9 per cent which is present as FeO (63.64 per cent) and Fe_2O_3 (36.86 per cent). Consequently the formula for the active iron mass in an uncharged condition is $4FeO, Fe_2O_3$ or Fe_5O_7. By means of these values, and with a knowledge of the capacity of an iron plate, it is not difficult to determine the coefficient of utilization of the iron mass. The weight of the entire active mass of an iron electrode of 24 briquette units is:

$$5.136 \times 24 = 123 \text{ grammes,}$$

which consists of $123 \times 0.74 = 89$ grammes of iron and 20 grammes of mercury.*

The 89 grammes of iron should, theoretically, give a capacity of 84.5 ampere hours when changed to FeO, the nearest oxidation step. In the practical tests, however, only 32 ampere hours were developed in a five-hour discharge, so that an effective utilization of only 27 per cent was accomplished. If the quicksilver be taken into consideration, and the change of the iron into red ferric oxide be regarded as a basis, the result will be still less.

Though the principle, used by Edison, of the perforated metal pockets with interiorly placed mass-brickets is excellently carried out constructively, there can be no doubt that this is merely a makeshift which we will be compelled to use as long as we are unable to loosen the active masses, similarly as in the lead accumulator, and then by other means to bring them into good contact with the holders. Probably if an improvement in this respect were made, the useful effect, at present still the weakest point, would be increased.

INTERIOR OF THE PLATES.

The original means of insulation, consisting of corrugated and perforated hard-rubber partitions, are replaced between the mass-briquette in a longitudinal direction. A nickel-plated iron bolt passes through tap holes in the shanks of similar pole electrodes. To this is secured the plate clamp, which is tightened and held in place by two nuts upon the bolt. The electrodes rest upon parallel hard-rubber bars which are notched at their upper extremities. These bars, together with the shorter ones which join them, form a connected framework. A similar notched hard-rubber framework is used to insulate the electrodes from the walls of the jar.

ELECTROLYTE.

Sulphuric acid of the highest conductivity (specific weight 1.23) is considerably better in this respect than caustic potash (specific weight 1.29) of the highest conductivity found in this substance. This disadvantage, however, of the alkaline electrolyte is offset in the Edison accumulator by the possibility of bringing the electrodes very closely together, i. e., within about 1.5 millimeters of each other. The conductivity curve of caustic potash (Elektrotechnische Zeitschrift, 1903, No. 32) gives a very much flatter maximum for a 30 per cent solution. As with the lead accumulator, it is of advantage in the Edison accumulator to use an electrolyte which does not give the highest possible degree of conductivity. If a vessel be filled with a 30 per cent solution of caustic potash, it will be found that after a few days the middle stratum alone has retained its concentration, and consequently the highest degree of conductivity, while the strata above and below have changed in this respect. If the experiment be repeated with, say, a 20 per cent solution, it will be found that the lower layers possess the highest conductivity, while the average of the whole column of liquid has remained the same as in the first test. Analogous actions take place in the concentration changes, which occur at the electrodes when current

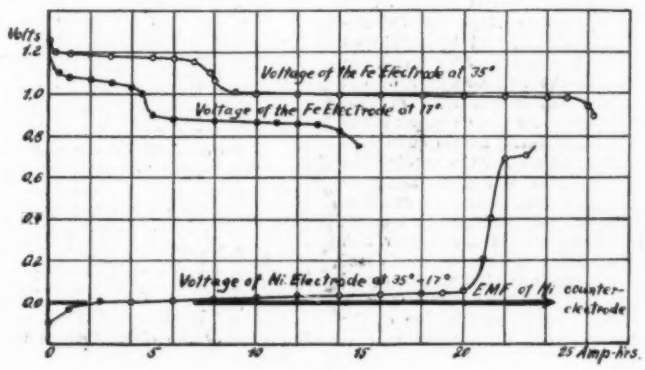


FIG. 7.

* The analysis which was made by Mr. Liagre and kindly placed at my disposal is of an Edison iron electrode, which in regard to appearance and measurements corresponds to the element discussed herein, but, however, possesses a greater weight, i. e. 200 grammes, with, on the other hand, a smaller capacity.

is passing, because of the different velocities of migration of the K and OH ions. Aside from the greater weight and the higher price of the concentrated solution, the formation of a ferric compound of potassium, that is to say, the dissolving of the iron, is a further disadvantage. Probably for these reasons does Edison recommend the use of a 20 per cent solution only. Especially important is great purity of the electrolyte, as otherwise heavy self-discharges (organic substances) or burdensome foaming (inferior hard rubber, fat, oil) takes place, and the faultless action of the cell is thereby jeopardized. The top is sealed hermetically, so that the surface of the liquid can only come into contact with the gases evolved during charging, and never with the atmosphere, as in the latter case a slow but steady absorption of carbonic acid from the air by the electrolyte would occur with a simultaneous formation of carbonate. That the volume of the electrolyte in the Edison accumulator may be comparatively very small is due to the fact that here the electrolyte serves solely to transport the oxygen from one electrode to the other, while in the lead accumulator the sulphuric acid, as is well known, takes part in the current-forming reactions at both electrodes, in the quantitative formation of sulphate, and hence the concentration of the acid varies in charging and discharging. In the Edison accumulator the electrolyte undergoes substantial changes only in volume, temperature, and conductivity.

As it is particularly prescribed in the catalogue of the Edison Storage Battery Company that the battery should be refilled with nothing but pure water, it appeared to me that it would be interesting to test the stability of the density of the electrolyte after a certain period of use. The first test of this character took place after forty days, counting from the beginning of the experiments, and after about thirty-five charges and discharges, and the specific weight was found to be 1.17, as against 1.19 at the beginning of the investigation. This slight difference is undoubtedly due to a number of forced charges at 80 to 100 amperes during which the valve partially failed, and some of the solution was accidentally forced out and then removed by means of a blotter. As a strong decomposition of water takes place in consequence of the overcharging, and as the changes of level are pronounced because of the high form of the cell, the re-filling of the same with water must be frequently and conscientiously attended to. If the caustic potash be replaced by alkaline gelatine, possessing about the consistency of sulphuric acid gelatine, the capacity of the accumulator decreases from 30 per cent to 40 per cent, a proof that the good diffusion of the solution is exceedingly important, notwithstanding that the solution does not change from the liquid to the solid form as does the sulphuric acid in the lead accumulator.

TESTS.

The tests were undertaken to determine:

1. The capacity in ampere hours.
2. The output in watt hours.
3. The influence of the current strength and the temperature of the electrolyte upon capacity and output.
4. The action of the individual electrodes.
5. The temperature changes of the electrolyte in charging and discharging.
6. The efficiency in ampere or more particularly watt hours.

Besides the complete cell, hermetically sealed by soldering, a number of nickel and of iron electrodes was available for these tests, and by means of these the investigation of the individual electrode was more convenient and reliable than would have been possible by means of the entire cell. In the latter case the investigator is forced to use the nickel-plated steel jar as an auxiliary electrode, the capacity of which, even with the use of instruments of high resistance, is far too small to permit the taking of reliable readings with safety.

For example, take the action of the terminal voltage for the periods of charging and discharging, with a constant current strength ($i = 40A$). As in the lead accumulator, the tension rises rapidly at the beginning of the charging (Fig. 3), i. e., from 1.5 V., the value corresponding to the E. M. F. of the cell, to 1.72 V. It then falls slowly to 1.7 V., reaches 1.8 V. near the second third of the charging period, and by continued overcharging attains the value 1.86 V. The formation of gas, in accordance with the low efficiency of the Edison accumulator, begins rather quickly, even with reasonably low current values. As the charging curve shows, it is difficult safely and rationally to determine the end of the charge, and thus, also, the readings of the electrolyte temperatures give only uncertain stopping points, as will be seen from the temperature measurements below. If the charging circuit be opened, the E. M. F. falls rapidly at first, more slowly later, and after a number of hours, takes the constant value of 1.5 V. Qualitatively, this curve is similar to that of the lead accumulator, and as with that curve, is probably conditional upon the gradual equalization of the pore fluidity of the free electrolyte between the electrodes.

If the capacity of the accumulator be very slightly decreased the E. M. F. does not return to the value 1.5 V., but takes a value of 1.42 V., a fact which is due to the use of the nickel electrode.

At the beginning of the discharge at 40 A., the voltage falls very rapidly from 1.5 V. to 1.3 V., then more slowly and gradually to 1.15 V., and after the withdrawal of 135 ampere hours, suddenly to 0.65 V. Up to this point the discharge curve of the Edison accumulator is very similar to that of the lead accumulator. While, however, in the lead accumulator, the approaching end of the discharge is indicated by the very rapid fall in voltage, and the polarity of the cell is reversed if the discharge be continued further, in the Edison accumulator the discharge can be continued for some time with the tension remaining at 0.65 V. or with a lower current value at 0.75 V. The length of this "residual discharge," so characteristic of the Edison accumulator, is about equal at an average to one-tenth of the entire discharge period. In general, the lower the discharge current, the sharper will be the bend of the curve; in a ten-hour or longer discharge, the curve falls off almost at right angles. For the calculation of the capacity available for practical purposes, it is of course, hardly permissible to take the residual capacity into consideration. The latter, however, may be very handy, for instance, in the case of an exhausted storage-battery vehicle which it is desired to place under cover, even if only at a snail's pace.

It is obvious that the different voltages are simultaneously caused by different reactions upon one of both, or upon both electrodes, and as a matter of fact, the nickel, as well as the iron electrodes, have a so-called "double voltage." Under normal conditions, as well as at this discharge, the capacity of the six iron electrodes decidedly preponderates over that of the twelve nickel ones, so that the resulting total capacity of the cell is limited by the capacity of the nickel electrodes, and the discharge curve of the accumulator at the same time represents the characteristic of the nickel electrodes. The individual action of the separate electrodes will be discussed later. The duration of the discharge, at least within the limits which we set for all practical purposes, has no influence upon the capacity in the Edison accumulator, the former differing in this respect from the lead accumulator. In fact, in some cases a slight increase in capacity was noted for very high discharge currents ($i = 150A$), probably due to the better diffusion and conductivity of the electrolyte in consequence of the rise of the temperature. In common with Janet, Hospitalier, Hibbert, and others, I was unable to disoover any damage due to extraordinarily high charge and discharge currents, and as there can be no doubt that the possibility of a very rapid charging is in many cases particularly desirable, in this, as well as in the fact that the capacity is independent of the current strength, the Edison accumulator is superior to its rather cumbersome rival.

The main point of interest in the discharge of an accumulator is, however, not alone the capacity and its connection with the current strength, but is chiefly the watt-hour output as a function of the discharge current strength. Unquestionably, a discharge is characterized rather by the watt-hours that it gives, than by the number of ampere-hours. Then if we use the watt-hours drawn from the accumulator instead of the time or the time × amperes (as is usually done) upon the abscissa and the corresponding voltages upon the ordinate of the curve, the action of the accumulator with respect to the capacity and watt-hour output, and their dependence upon the discharge current strength, will be clearly apparent. As is shown in Fig. 4 by the curves for 10, 50, and 80 A.'s, the cell yields 191 watt-hours at 10 A., and at 80 A. a discharge current eight times as great, 156 watt-hours, that is to say, only 17 per cent less. The average tension has fallen, meanwhile, from 1.32 V. to 1.145 V. (a difference equal to 13.2 per cent). The value 1 V. has been fixed as the lower discharge limit for all the curves.

The following table shows the capacity obtained during strong over-discharges, and here too may be remarked that, as indicated above, in this series of tests the object throughout was to obtain the most favorable results possible, irrespective of efficiency or other conditions.

Discharge Current Strengths in Amperes.	Ampere-hours.	Ampere-hours per 1 Kilogr.	Voltage.	Watt-hours er 1 Kilogr. with 1 V. as Discharge Limit.
80	153	24.10	1.145	27.59
50	144	16 18	1.220	31 93
40	138.7	25.20	1.242	31 29
20	144	26.18	1.262	33.00
20	128.7	23.40	1.290	30.18
10	145	26.36	1.320	34.79

The table shows individual discrepancies. Thus, the capacity during a discharge at 20 amperes is only 128.7 ampere-hours, a value decidedly less than 144 ampere-hours, the capacity during a discharge at 50 A. The smaller capacity in the first case is due to the fact that the discharge preceding the one at 20 A., as well as this discharge itself, took place in a room at a lower temperature, and consequently with the electrolyte at a lower temperature.

THE INFLUENCE OF THE TEMPERATURE UPON CAPACITY AND PERFORMANCE.

As can be seen from the above-mentioned fact, the influence of the electrolyte temperature upon the capacity and tension is very marked, and apparently so to a greater degree than in the lead accumulator. With the latter, the ± capacity changes vary according to the thickness of the plates and the discharge current strength between 1 and 2½ per cent for every degree Centigrade. Twelve years ago, in Moscow, I had an opportunity for making tests on an illuminating battery of the Imperial train while the temperature of the outer air was —30 deg. and in which the temperature of the acid was approximately 0 deg. According to these investigations, the current-producing ability of a lead battery is strongly affected by unfavorable temperature conditions of this kind, but the loss in capacity remains within practically permissible limits (40 to 50 per cent loss). Similar observations were made by Nansen on his North Polar expedition, with respect to a Tudor accumulator. Now an Edison accumulator would, under similar circumstances, fail almost entirely, as demonstrated by Figs. 5 and 6, where the action of the cell is represented under normal and abnormal temperature conditions by a number of charge and discharge curves. The investigations to determine the temperature influence were partly conducted in the following manner:

During the night the cell was charged in ten hours at 30 A., and then in the morning it was placed in a large sheet-iron vessel containing a mixture of ice and water. Under these conditions the temperature of the caustic potash fell to 4.5 deg. C. in 25 to 30 minutes, whereupon the discharge was at once begun. In order to obtain the readings of the temperature changes of the electrolyte, a rubber stopper was placed in the filling vent of the top, and an exact thermometer inserted into the cell through a round opening in this rubber stopper. Every test was followed by a check test under exactly similar conditions, for the first few discharges undertaken with the cold solution caused the belief to arise that some pronounced error had been made in the method of investigation, a fact in no wise substantiated in the later experiments. Most noticeable in the results obtained from a large number of discharges (at 50 A., and especially 30 A.) is the fact that the characteristic of the curves is entirely changed, and in addition, that the deformation is greater with larger currents, when the discharge takes place with a cold electrolyte. While, for instance, with a normal discharge at 50 A. the average tension is 1.22 V., and the first rapid fall in voltage does not occur till after 130 ampere-hours have been drawn from the battery, the voltage curve in the case of the chilled electrolyte shows the first decided voltage alteration shortly after 25 ampere-hours, and a second jump shortly before the zero value is reached. The two bends present in the normal voltage curve are recognizable here too, even if somewhat indistinctly. By fixing the lower voltage limit at 1 V., the resulting capacity is only 12 ampere-hours as against 144 ampere-hours under normal conditions.

It should be remarked that the temperatures of 33 deg. and 32 deg., shown in Fig. 5, represent average values, as the electrolyte at the beginning was at the temperature of the room (about 18 deg. or 19 deg.) and during the discharge this reading rose to 42 deg. and 46 deg. The temperature of the cold solution, when the cell was surrounded by ice-water, did not vary more than 1 deg. to 2 deg., and did not begin to rise regularly and noticeably until the first rapid voltage change, simultaneously with which a decided increase in the internal resistance of the cell took place.

In another series of tests the accumulator was placed in a water-bath, without ice, and allowed to remain uninterruptedly therein during a large number of charges and discharges. As water, in comparison with air, is a good conductor of heat, the heat produced in the cell by the passage of the current was constantly eliminated by radiation so that the temperature of the electrolyte during the entire period of the test approximated the temperature of the room. The density of the solution during these tests was about 1.15. The capacity, 136 ampere-hours under normal conditions, an average temperature of say, 30 deg., falls to a value practically inconsiderable, i. e., 20 ampere-hours. Shortly after the beginning of the normal charging the hump characteristic of the Edison accumulator appears in the curve to remain for about an hour at the value 1.73 V., and does not rise again until the accumulator has received a charge of 160 ampere-hours. In charging in the water-bath the curve begins at 1.3 V., rises at first rapidly and then more slowly, to take the constant value 1.9 V. after about an hour. As shown in Fig. 6, the curves for 80 A. are effected in about the same degree by the water and by the ice bath.

No efficiency determinations were undertaken with abnormal temperature conditions, but from the curves alone we are able to deduce that the efficiency decreases with falling temperature. In other words, the warmer the electrolyte the better is the action of the Edison accumulator. It would appear that the coating of black varnish given to the cell has an excellent effect in this respect. In tests with the electrolyte at very high temperatures, it was proven by the play of the gas-valves that gas was being formed when the cell was in a state of rest. The analysis of this showed it to be pure oxyhydrogen gas, so that self-discharge must have taken place at both plates. Further experiments with changes of the electrolyte temperature are, therefore, extremely advisable in order to determine practically the most useful limit for the range of these temperatures.

In the investigation of the individual action of the nickel and iron electrodes, it appeared of interest to me to determine how the decrease in capacity due to cold electrolyte was apportioned between the electrodes. It was natural to presume that the extraordinary behavior of the Edison accumulator at low electrolyte temperatures was due to some diffusive action, similar to that which was known to be the case in the lead accumulator. In the latter, the decrease in capacity is caused by a retardation in the exchange of acids. And in fact here the temperature effect upon the capacity of the peroxide of lead plate is somewhat greater than that upon the spongy lead plate, as water is formed in the pores of the former during the dis-

charge. In the Edison accumulator, the following astonishing observation can be made: the nickel electrode changes neither in capacity nor in voltage with the temperature; in other words, the abnormal action of the cell, while discharging with a cold electrolyte, is caused entirely by the iron electrode (Fig. 7). As may be seen, the capacity of the iron electrode falls from 25 ampere-hours ($i = 5$ A.) at a temperature of 35 deg., to about half this value at 17 deg., while for the same difference in temperature, no influence upon the alkaline solution at the nickel electrode, and no effect upon the form of the curve have been determined. A nickel electrode, the E. M. F. of which is represented upon the zero ordinate, served as the currentless auxiliary counter-electrode for the observation of both component voltages.

Without going into the details of the reactions occurring at the electrodes when current is passing, the action which takes place during the electrolysis of insoluble electrodes in unchanging electrolyte, may be briefly mentioned here.

As E. F. Roeber* first, upon a basis of purely theoretical reasoning, and Schoop† afterward experimentally demonstrated, decided and strong concentration changes occur at the nickel and iron electrodes during a passage of current because of the different migration velocities of the K and OH ions, while, however, the average concentration, in other words, the original potassium hydroxide content, remains unchanged in the electrolyte. If, for instance, $2 \times 96{,}540$ ampere-seconds are passed through the accumulator (96,540 ampere-seconds = the electrical charge of a gramme equivalent), 2 *g*-ions are liberated at the iron electrode and 2 *g*-ions at the nickel electrode. If we write the reactions occurring at the two electrodes according to Roeber's proposal:

$$Fe + 2OH = FeO + H_2O$$

and

$$NiO_2 + 2K + H_2O = NiO + 2KOH$$

we recognize at once after the formulæ have been contracted, that a molecule of water has been formed at the iron electrode, and a corresponding molecule of water has disappeared from the nickel electrode, so that the electrolyte must have become more dilute at the former and more concentrated at the latter. In the lead accumulator, during the discharge an impoverishment of the acid takes place in the interior of both plates, but particularly at the peroxide of lead plate, while on the other hand, in the Edison accumulator, a dilution of the electrolyte occurs only at the iron electrode, and the caustic potash solution at the nickel electrode constantly becomes more concentrated as the discharge progresses. It is now apparent why the temperature changes are only effective at the iron electrode, but it would be natural to ask why the Edison accumulator does not show a decrease in capacity under the very rapid discharges, as for the faultless current-producing action of the latter an active diffusion is at least as important a consideration as for the lead accumulator. The answer lies therein that a decided dependence of the capacity upon the current strength is also present in the Edison accumulator in case the thickness of the mass-briquettes increases to a number of millimeters from 1.5 millimeters, and the iron electrode does not contain a measurable surplus of capacity.

On several occasions I had an opportunity to compare the Edison iron electrode with other iron electrodes 4 to 6 millimeters in thickness, and the experiments actually proved that the typical action due to the diffusion was: dependence of the capacity upon the current strength, and so-called recovery after an interruption of the discharge.

As mentioned above, within wide limits of the electrolyte concentration, the E. M. F. of the Edison accumulator is 1.5 V. after completed charging. However, after the withdrawal of a small part of the capacity, this value is not again reached, the E. M. F. in fact returning to 1.4 V. As shown by Fig. 7, this originally high E. M. F. is caused by the nickel electrode at which, in all probability, an unstable highly oxidized nickel-oxygen combination is formed. The Edison accumulator, therefore, shows in this instance also a behavior different from that of the lead accumulator, as with the latter, in a state of rest, the E. M. F. is produced by the concentration of the electrolyte inside and outside of the pores of the plates.

The electrodes here investigated are the product of an earlier manufacture, and despite their greater weight possess a capacity substantially less than that of the electrodes comprised in the latest Type E. These are the electrodes (Type D) upon which the above stated analysis was made. The present E-plates are therefore to be considered as improved forms of the plates of the D type and they are actually superior to the latter. A Type D iron electrode gave a maximum capacity of 32 ampere-hours at a 5 A. discharge current, while a nickel electrode of a similar type with the same discharge current gave 20 ampere-hours.

(To be continued.)

CONTEMPORARY ELECTRICAL SCIENCE.‡

ACTIVE PRODUCTS FROM URANIUM.—H. Becquerel has followed up the radio-activity derived from the solution of uranium and radium salts. When uranium chloride is dissolved in water with a little barium chloride, and the barium is precipitated by means of sulphuric acid, the sulphate is more active than the original uranium salt, but its activity is halved in about twenty-two days. The activity of the uranium is diminished at first by the precipitation, but it subsequently recovers itself owing to the further evolution of its emanation. Radium salts show similar effects, and if both uranium and radium salts are used together, their effects are simply added, without interfering with each other. Heat seems to have no effect on either of them, and since the emanation products are deposited on most kinds of finely-divided matter, the author was led to boil lampblack in a solution of uranium chloride and then to calcine it in a platinum crucible. The carbon was thus burned away, and left a number of black grains of high radio-active power which had all the properties of uranium oxide, but could not be weighed. Its radio-activity was several thousand times that of the black oxide of uranium. On dissolving the grains with hydrochloric acid they left a less active residue, whereas the dissolved portion was quite inactive, and remained so.—H. Becquerel, Comptes Rendus, July 10, 1905.

MINIMUM AUDIBLE SOUND.—P. E. Shaw has investigated the amplitude of the vibrations of a telephone diaphragm by means of his electric micrometer. Previous workers, notably Rayleigh, found amplitudes ranging from 0.05 $\mu\mu$ to 1.3 $\mu\mu$ for the minimum audible continuous sound. The author finds the value 0.7 $\mu\mu$ for an impulsive sound, given a sensitive ear and a telephone of the usual construction whose diaphragm fundamental is about 580. He determined first the displacements produced by a series of steady telephone currents by the micrometer. Then, employing the same currents, he determined at what point the click due to the release of the diaphragm became inaudible. The sound was impulsive, for the diaphragm was released from a position of strain, vibrated under considerable damping, and soon came to rest. The author draws up the following table of amplitudes for sounds of various intensities: Just audible 0.7, comfortably loud 50, uncomfortably loud 1,000, and overpowering 5,000 $\mu\mu$. The amplitudes of air molecules for the same sounds are one-fifth of the above. The greatest known amplitude, giving the loudest sound, is a quarter of a millimeter, that being the amplitude within two yards of the muzzle of a gun when fired.—P. E. Shaw, paper read before the Royal Society, April 13, 1905.

EVOLUTION OF HYDROGEN FROM CATHODES.—C. A. Skinner has found that all cathodes give off hydrogen as well as cathode rays, and that the amount of hydrogen thus evolved obeys Faraday's law of electrolysis. When the cathode is immersed in oxygen, water is formed, when in nitrogen, ammonia is formed, but when it is immersed in hydrogen, all the hydrogen evolved by the cathode is transmitted to the anode, and is there absorbed. When all the hydrogen is driven off, it recovers after several hours, and most rapidly in the case of silver. A silver cathode was depleted six or eight times during the course of two weeks, and gave off the same amount of gas each time. After this the silver was removed from the tube, repolished, then tested again with the same results. Altogether about 2 cubic centimeters of gas were given off by this silver disk, which is 15 millimeters in diameter and about 1 millimeter thick. It showed no sign of having its supply of hydrogen reduced in the least. There are other metals of which cadmium is an example which seem to possess more of a surface charge of hydrogen. This metal, however, seems to reach an apparently depleted condition before the hydrogen it really possesses (measured by vaporizing the surface) is half gone. A comparison of the length of time the different metals follow Faraday's law in furnishing hydrogen brings to light an interesting relation between this and their cathode fall when fresh. It is a well-known fact that aluminium and magnesium possess in all gases a lower cathode fall than the rest of the more electronegative metals. With the difference in cathode fall aluminium and magnesium are to be distinguished from the other metals in a more striking manner by the freedom with which they continue to give off hydrogen. These results suggest that there must be an intimate connection between the cathode fall of the fresh metal and the length of time the metal continues to furnish hydrogen.—C. A. Skinner, Physical Review, July, 1905.

Certain as it is that fire is the greatest of forest evils, there exists comparatively little accurate knowledge on which to base an estimate of the total loss from this source. This is due not to lack of interest so much as to the immensity of the field and the complex character of the problem which the attempt to make such an estimate presents. Losses of mill and logging machinery, lumber, cordwood, merchantable standing timber, and other property of stable market value can be closely determined by individual losers, but when attempts are made to combine even these definite losses for a State, or for the United States, the result becomes a rough estimate, if not a matter of mere conjecture. Nevertheless, it is indisputable that these losses are enormous, and that, for the country as a whole, they run high into the millions. The most conservative estimates put the average annual loss from forest fires at above $25,000,000. More exact estimates are available for limited regions. For example, a careful estimate made on the ground after the terrific Washington and Oregon fires of 1902 showed a loss in nine days of $12,000,000 worth of forest property. New York State in the spring of 1903 suffered from unusually severe fires in the Adirondacks, involving a direct loss estimated at $3,500,000, in addition to a known expense for fire fighting of $175,000.

TRADE NOTES AND FORMULÆ.

Acid-Free Soldering Fluid.—Five kilogrammes of zinc chloride, dissolved in 25 kilogrammes of boiling water. Or 20 kilogrammes of zinc chloride, 10 kilogrammes of ammonia chloride, dissolved in 100 kilogrammes of boiling water and put into glass carboys.—Der Chemisch-Technische Fabrikant.

Incombustible Bronze Tincture.—Five kilogrammes of prime Dammar resin and 1.5 kilogrammes of ammonia soda, very finely pulverized. Heat gently, with frequent stirring, until the evolution of carbonic acid ceases. Then take from the fire, and when cool, pulverize again. Put the powder into a glass carboy, and pour over it 50 kilogrammes of carbon tetrachloride; let this stand for two days, stirring frequently, then filter. Ten kilogrammes of the fluid are to be mixed with each 5 kilogrammes of metallic bronze of any desired shade, and put into bottles. Shake the tincture well before using.—Der Chemisch-Technische Fabrikant.

Carbolineum.—Sixty kilogrammes of black coal tar oil of a specific weight higher than 1.10, 25 kilogrammes of creosote oil, 25 kilogrammes of beech-wood tar oil, of a higher specific weight than 0.9. Mix together and heat to about 175 deg. C., or until the fumes given off begin to deposit soot. The resulting carbolineum is brown, and of somewhat thick consistency; when cool it is ready for use and is packed in casks. This improved carbolineum is applied to wood or masonry with a brush; the surfaces treated dry quickly, very soon lose the odor of the carbolineum, and are effectively protected from dampness and formation of fungi.—Der Chemisch-Technische Fabrikant.

Stamping Colors for Use With Rubber Stamps.—Blue: 0.3 kilogramme of water-blue 1 B, 1.5 kilogrammes of dextrin, 1.5 kilogrammes of distilled water. Dissolve the aniline dye and the dextrin in the distilled water, over a water bath, and add 7 kilogrammes of refined glycerine, 28 deg. Bé.

Other colors may be made according to the same formula, substituting the following quantities of dyes for the water-blue: Methyl violet 3 B, 200 grammes; diamond fuchsin I, 200 grammes; aniline green D, 400 grammes; vesuvine B, 500 grammes; phenol black, 300 grammes. Oleaginous colors are mostly used for metallic stamps, but glycerine colors can be used in case of necessity.

Oleaginous Stamping Colors.—0.8 kilogramme of indigo, ground fine with 2.5 kilogrammes of linseed oil varnish, and 0.5 kilogramme of olein. Add 2 kilogrammes of castor oil and 5 kilogrammes of linseed oil. For other colors according to the same formula, use the following quantities: Cinnabar, 2½ kilogrammes; verdigris, 2½ kilogrammes; lamp black, 1.2 kilogrammes; oil-soluble aniline blue A, 0.35 kilogramme; oil-soluble aniline scarlet B, 0.3 kilogramme; aniline yellow (oil-soluble), 0.45 kilogramme; oil-soluble aniline black L, 0.6 kilogramme.—Der Chemisch-Technische Fabrikant.

Utilization of the Residue from the Distillation of Rosin.—The residue from the distillation of rosin is sent out under the German name of Schmiedepech. It can also be burnt to lampblack. This is done in specially constructed ovens, but only an inferior quality is obtained. Of more consequence is the utilization of the acetic liquids passing off in the distillation. These are neutralized in large vats; calcium acetate is formed, and an insoluble brown compound of the lime with the resinous substances is deposited and drawn off. The liquid, cleared by filtration, is evaporated to 15 deg. Bé., and a concentrated solution of Glauber's salt is added as long as there is any deposit of calcium sulphate. Not all, however, of the calcium acetate is changed to the sulphate, and therefore the undecomposed residue is precipitated by means of sodium carbonate, in the form of calcium carbonate. The liquid separated from the precipitate by filtration, and containing only sodium acetate and a little calcium sulphate, is evaporated to crystallization in shallow cast-iron kettles, during which process there is a continued precipitation and removal of resinous products. The point of crystallization is reached at 15 deg. Bé., and the liquid is let off into the crystallization vats. In the course of four days the sodium acetate will separate in large crystals. The crystallization process is repeated once or twice again. The sodium sulphate obtained is now melted in a shallow cast-iron kettle. This salt is first melted in its water of crystallization, after the evaporation of which it becomes solid and must be melted again at a higher temperature. The mass puffs up, and oily fumes are given off, at last it runs quietly, and is then taken from the kettle, dissolved while still hot in soft water, and filtered. The filtrate is allowed to crystallize, the sodium acetate is decomposed by means of English sulphuric acid in an iron still with a lead lining and lead or copper head, and the acetic acid is distilled out. The acid thus obtained is rectified again in glass retorts, with a little manganese peroxide, and should be as clear as water, with no foreign odor. Iron acetate can be obtained as a by-product, if the acetic liquid is put into barrels filled with bits of sheet iron and iron filings and shavings. In from eight to fourteen days the saturation of the liquid is effected, the process being hastened by bringing the contents of the barrels into contact with the air, and by keeping the temperature of the liquid at 20 deg. or 25 deg. R. through the introduction of heated vapors. But saturation does not always take place in the barrels, and the liquid is drawn off into cast-iron kettles, filled with scraps of iron, and heated to boiling. The resinous portions,

* El. World and Eng., 1901, No. 26.
† Electrochem. Ind., 1904, No. 7.
‡ Compiled by E. E. Fournier d'Albe in the Electrician.

which rise to the top, are removed, and the boiling continues until the saturation of the acetic liquid is complete. It is then evaporated to 10 deg. or 15 deg. Bé., and allowed to settle thoroughly before use.—Drogisten Zeitung, Vienna.

SCIENCE NOTES.

With the rapid growth of population and the shifting of industrial centers there have been constant changes in agricultural practices. A study of the world's history shows that while agriculture has been, and will continue to be, the primary basis of wealth, it has reached its highest development where most closely allied with the factory. No country can continue to be prosperous where agriculture is the sole dependence, nor can any country hope to be independent and enjoy the best fruits of its industry where manufacturing constitutes the chief source of wealth. The farm and the factory must go side by side in order to bring about the greatest progressive, intellectual, and industrial development.

The investigations of Dutton and Todd on tick fever in the Congo Free State, announced in February, have gone to prove that this disease is transmitted by a tick (*Ornithodoros savignyi*) after it has infected itself with blood containing the Spirochætæ. This has been confirmed by Koch, if we may rely on what has appeared recently in German newspapers. It is, however, quite premature to assume that African tick fever and European relapsing fever are due to one and the same species of Spirochætæ; in fact it is highly probable that this is not the case, although the report in question refers to the Spirochætæ as one species. In relapsing fever in Europe the bedbug (*Cimex*) has long been suspected to be a carrier of the infective agent, a probability which was considerably heightened by Karlinski's observation of motile Spirochætæ in the bodies of the insects up to thirty days after they had fed on relapsing fever blood. Schaudinn, moreover, informs us that he has observed the multiplication of the *Spirochæta obermeieri* in Cimex. These observations, following closely upon those published by Marchoux and Salimbeni, are of greatest interest and practical import. The last-named authors demonstrated that a fatal disease of the fowl in Brazil is due to a Spirochæta which is transmitted through the agency of a tick (*Argas miniatus*), and this is capable of conveying the disease even six months after feeding on infected blood. These Spirochætæ multiply in the tick, and are present in large quantities in its body cavity throughout this period. These observations are very suggestive, since they demonstrate the long persistence of the parasites in their carriers, and render it probable that they will be found to be harbored much longer. Finally, the finding this year of *Spirochæta pallida* in syphilis by Schaudinn and others in man, and by Metschnikoff and Roux in experimentally infected apes, cannot escape a passing notice.

Important problems in the general study of photosynthesis may well begin with that of a better knowledge of the structure of chloroplasts and the constitution of chlorophyl. Neither of these, however, is absolutely essential to further physiological observations of a fruitful kind. One of the questions long ago raised is still pertinent: what is the connection between chlorophyl and the plastid in which it is embedded? An answer to this question may perhaps afford in time an answer to the general inquiry as to the location of the true photosynthetic property. If chlorophyl is always the same chemically, it is perhaps probable that the first product of photosynthesis may always be the same, although this is not necessarily true. In any case, the chief problems hinge upon the method of decomposition of carbon dioxide and water and the synthesis of the first organic product. Neither the hypothesis of Bayer, Erlenmeyer, Crato, Bach, Putz, nor any other, has, to any considerable degree, been made capable of experimental proof, although that of Bayer has been most generally accepted. Each of these assumptions offers some suggestions for future work. Perhaps it may as well be said that they, to a certain extent, bias future research. Nevertheless, even when the chemical reactions in this synthesis become known it may yet remain problematical how the energy of sunlight, that is, of those rays most absorbed, with wave length of 660 to 680 μ, is made available, or whether it is this energy directly or indirectly which is concerned in the decomposition. It has been well assumed that the light waves may not be immediately serviceable, but only after transformation into other forms of energy. Further, it is not known to what extent this energy is operative in subsequent transformations. The conditions under which photosynthesis occurs have been worked out with a fair degree of accuracy, the status of these problems having been well set forth by Ewart and others. It is known that when deleterious agents act at a given concentration merely to inhibit the assimilatory function (the cell not being permanently injured) there is no evident change in the chlorophyl, from which it has been inferred that the assimilatory arrest has its origin in the plasmatic stroma. In all cases photosynthesis cannot long proceed except under conditions of health of the protoplasts. Nevertheless, the effects of deleterious agents have not always been studied by very delicate tests, and further attention might be bestowed upon this matter by the use of the photobacterial method, or other delicate methods, recently suggested, for it is of considerable interest to determine the relation of the photosynthetic activity to such agents as compared with other activities.

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